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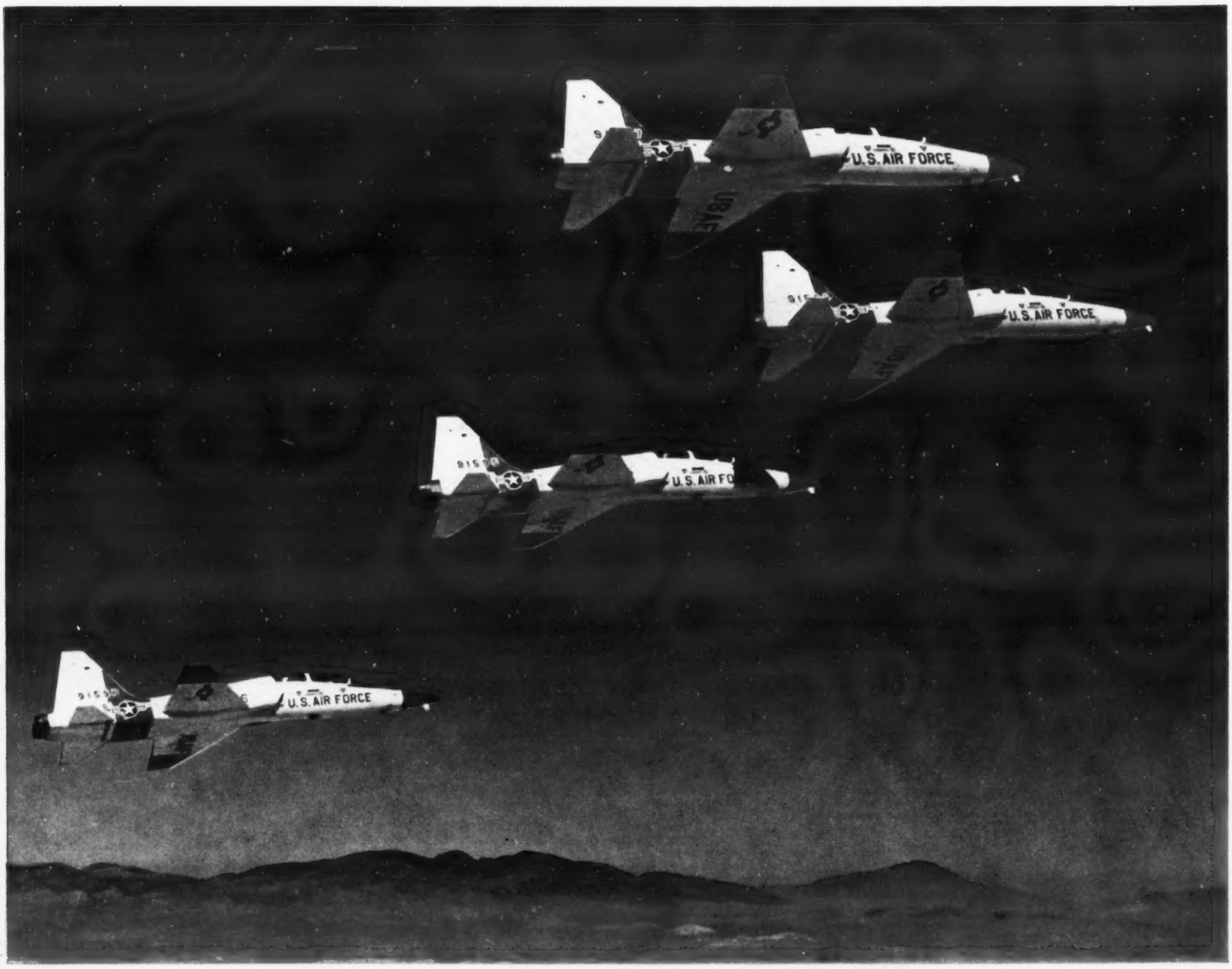
World Review of Aviation and Astronautics

with Electronics Supplement



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In this issue

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Boats on Wings • T-38 Talon Supersonic Trainer

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Volume XVI

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April 1961

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Paris-Orly Airport

Reflections on an Air Terminal . . . . . PIERRE D. COT 443
Building Design at Orly . . . . . HENRI VICARIOT 446
Layout of the Central Zone . . . . . JACQUES VASSEUR 449
Electrical and Thermal Power Supply . . . . . JACQUES BLOCK 451
The New Terminal Installations at Work . . . . . FRANÇOIS DIDIER 452
Air Navigation and Traffic Control Aids . . . . . RENÉ AUCOUTURIER 454
The New Hangar . . . . . EDOUARD BECKER 458

T-38 Talon Supersonic Trainer

A New Approach to Flight Training LT. COL. ARTHUR W. BUCK 463
The Northrop T-38 Supersonic Trainer 465
Flying the Talon — A Pilot Report. RICHARD L. SWEENEY 469
What's New in Electronics? 499
What's in the Air? 501
Freight Tariff way over the North Atlantic? 425

Speedboats on Wings

Hydrofoil Craft of Today and Tomorrow . . K. BÜLLER 479
The U.S. Navy's Hydrofoil Projects LT. COMMANDER W. NELSON 485
Bombers to Boats — Boeing Develops a 100-Ton Submarine Killer . . . . . ROBERT E. BATEMAN 486
Grumman Hydrofoil Boats 489
Lycoming Offers the Hydrophibian Concept — Fast Turbine-Powered Landing Craft 490

Front Cover : T-38A supersonic trainers in formation flight

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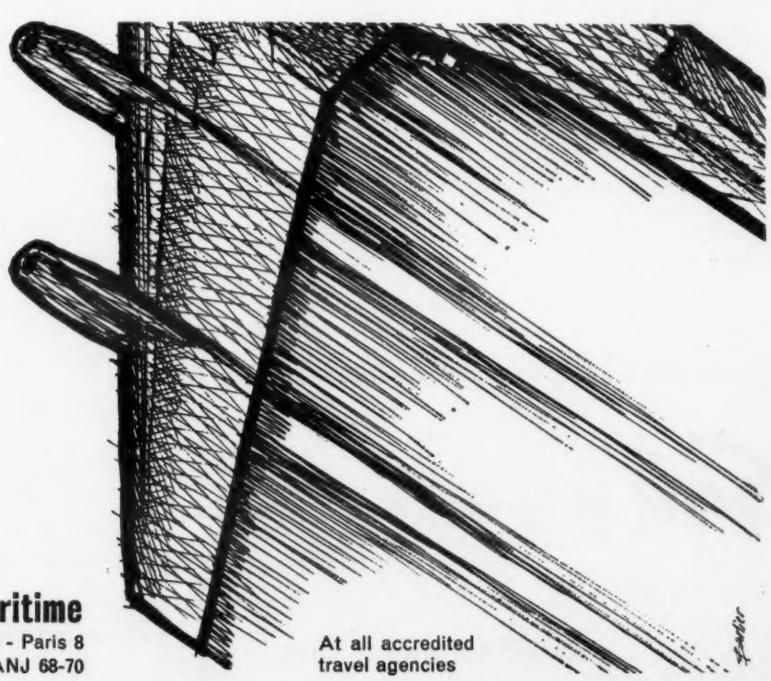

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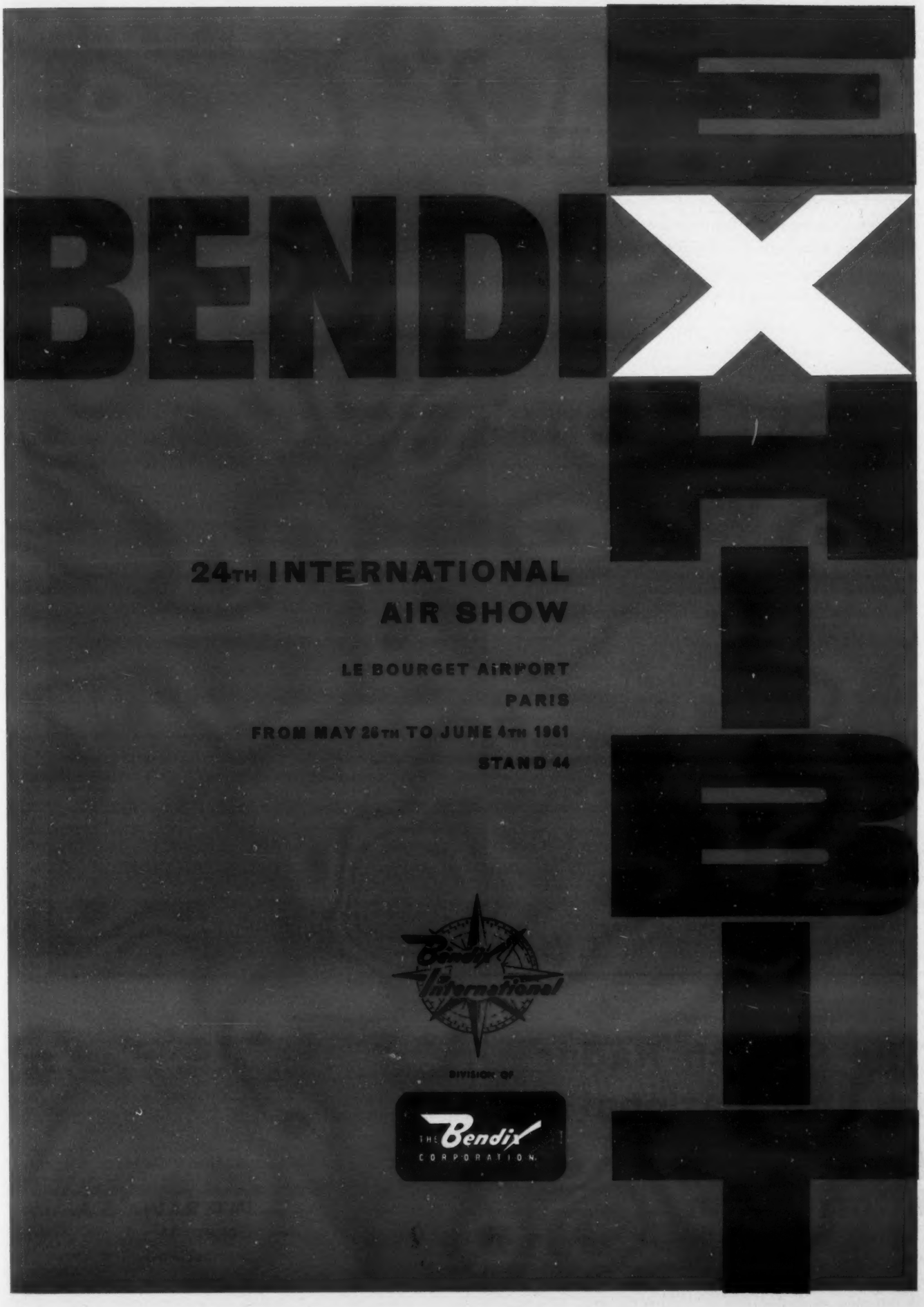
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INTERAVIA AIR LETTER reports...*

Air Transportation

Alitalia's new DC-8 service Bangkok-Pnom Penh-Djakarta-Darwin-Sydney will be inaugurated June 12th. Managing Director Bruno Velani says that negotiations are in hand to extend the Italian carrier's U.S. East Coast services to Los Angeles. Alitalia's 1960-62 investment programme for new aircraft and ground equipment will total 124,000 million lire ($198.4 m.).

●

Union Aéromaritime de Transport African services will be re-scheduled effective April 15th. DC-8 flight UT1301 will depart Paris each Tuesday for Brazzaville, Salisbury and Johannesburg. Flight UT1321 each Wednesday Brazzaville, Elisabethville and Johannesburg. UAT will also operate a regular DC-6B round-trip flight leaving Paris each Saturday on the route Nice-Fort Lamy - Bangui - Brazzaville - Elisabethville-Livingstone.

●

Transports Aériens Congolais is to be formed in Stanleyville to operate as flag-carrier for the Congo's Orientale Province. No details of aircraft to be utilized or routes to be operated have yet been announced.

●

Trans-Arabia Airways plans to open scheduled DC-6B service to London in May, but may introduce Boeing 707-120B transports on the route at a later date. The Kuwaiti carrier has an option on two American Airlines 120Bs, and a decision will be made sometime this month. The carrier wants to use jets to meet competition from Middle East Airlines and United Arab Airlines and would like to put Boeings on the Kuwait-London run by July. Trans-Arabia currently operates one DC-4 and two DC-6Bs on its Middle East routes.

●

Proposals for the merger of Iranian Airways and Persian Air Services have now been dropped. Iranair will not make a decision on new equipment until it is clear what government aid is forthcoming. The carrier is seeking a loan or subsidy for the purchase of new aircraft. A government decision regarding both domestic and international operations in Iran will be made later this year.

SAS has sold one Douglas DC-6B to the Finnish carrier Kar-Air O/Y (Helsinki) and three others to United Arab Airlines. Three DC-6Bs were recently disposed of to the Brazilian carrier REAL, but another sale for two DC-6Bs to Iranair has not been completed.

●

Swissair is discussing an order for a fourth DC-8 with Douglas Aircraft, but this is expected to be a series 50 (P & W JT3D turbofans) instead of series 30 as previously ordered. The series 50 DC-8 has been ordered by KLM (six), Iberia (three) and United Air Lines (two).

●

BEA will charter a DC-7C and *Britannia 312* (with flight and cabin crews) from BOAC this summer to compensate for delays in deliveries of 20 Vickers *Vanguards* on order. The DC-7C will be operated on the London-Zurich route in April and on some London-Paris flights June-August. The *Britannia* will be operated on routes to Copenhagen and Nice in April and May.

●

Eagle Airways (Bahamas) Ltd. has received U.S. Civil Aeronautics Board authority to serve Palm Beach, Fort Lauderdale, Tampa and Miami, all in Florida.

●

Aerolíneas Argentinas will purchase six Vickers *Viscounts* to replace DC-4s and DC-6s on the carrier's longer domestic routes. Nine Avro 748s have just been ordered and the carrier has four *Comet 4s* in service. The piston-engine fleet is to be sold.

●

U.S. Southern Transcontinental Route awards to Delta and National Airlines are expected to put both carriers in the market for new jet transports to handle expanded activities. National says it has a tentative requirement for six jets, but Delta has not yet reached a decision. Douglas, Boeing and Convair are making intensive sales drives on both carriers.

Industry

Boeing Airplane Company will increase prices of 720, 720B and 707-120B models by between 4.7 and 7.5 percent effective May 1st. Boeing 707-320/420 and 727 prices will not be affected. New prices are based on current engine costs reflecting various model improvements and the increased cost of materials and labour. Boeing prices range from about $4,250,000 for the 727 to over $6 million for the turbofan-powered 707-320B. Northwest Orient Airlines' recent order for six model 720Bs for delivery commencing June this year is valued at approximately $36,772,000 including spares.

●

Convair's order book for the model 880, 880-M and 990 jet transports now totals 97 aircraft. This includes two more 880-Ms for Japan Air Lines (to a total of 5), and a second for Venezuelan carrier Avensa. The Avensa 880-Ms will be operated by the new Venezuelan international carrier VIASA. Japan Air Lines will take delivery of the first three 880s this year commencing in June, and the last two in May 1962.

●

Garrett Corporation has received a $3 million Lockheed Aircraft Corp. contract to supply 180 central data systems for installation on Japanese Lockheed F-104J *Starfighters*. Garrett is already manufacturing environmental systems, starters and other components through licensing agreements in Japan. The new order brings Garrett's total contracts for F-104 equipment to $21 million, but total sales may finally be as high as $64 million, based on a figure of approximately 1,600 F-104 *Starfighters* for Japan, Canada and Europe.

●

Dynamics Corporation of America, manufacturer of military electronic and communications equipment, has established a European Division with headquarters in London. W. Allen Bridges has been appointed Director of European Operations. DCA already has a manufacturing-sales base in the U.K. through its subsidiary, Winston Electronics Ltd. Bridges joins the board at Winston Electronics and will have overall responsibility for DCA's European activities.

●

The Sperry Gyroscope Companies of New York and London have established a European subsidiary, Sperry European Continental Company, with headquarters at 7 avenue de l'Opéra, Paris. The new company will handle sales and service for Sperry equipment (flight instruments, automatic pilots, navigation equipment and radar) in Western Europe and will negotiate patents, licences and contracts for the companies' increasing European commitments. René Laureau (late of Société d'Equipements Aéronautiques Laureau & Cie.) is President and Director-General of the new company. Colin A. Richardson (of Sperry London) has been appointed Marketing Director for Europe.

●

Ekco Electronics Ltd. has signed a ten-year agreement with Wilcox Electric Company Inc. of Kansas City, giving the U.S. company licence production rights for Ekco weather radar equipment. Ekco engineering staff will work with Wilcox in preparation for U.S. production and in training personnel.

●

Breguet and Lockheed Aircraft Service are to cooperate on the maintenance of NATO and USAF aircraft stationed in Europe. Breguet has been active in the USAF's Chateauroux-Déols maintenance base for the past three years.

●

Tracerlab SA is the new company name agreed by shareholders of the Belgian company Physique Industrielle SA. Tracerlab Inc. of Waltham, Mass. holds 1,094 of the Belgian company's 1,600 issued shares and United States Trust Company of New York holds a further 500.

●

The French SFERMA company has fitted a Dornier Do 27 with an Astazou turboprop engine, under contract to Turboméca. Flight testing of the modified aircraft was commenced at Bordeaux last month.

●

Dornier Werke of West Germany is developing a small combat zone transport designated Do 31 for the West German Air Force under terms of a recent agreement with Defence Minister Strauss. Dornier had originally offered the Do 30 utility transport powered by two Bristol *Orpheus* turbines, with the intention of developing the aircraft to STOL and eventually VTOL capability. The new Do 31 project is a direct VTOL concept and will be powered by two Bristol BS.53s.

●

Marconi's Wireless Telegraph Co. Ltd. has received a French Government order to supply and install a type S232/2 crystal-controlled 50 kW 50-cm radar at the Centre d'Essais en Vol at Istres. The Istres flight

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test centre already has one Marconi S232 equipment which was installed some years ago. The order was placed through SIDEMA, Marconi's agent in France.

●

Sud-Aviation delivered six *Caravelles* to airline customers in the first quarter of this year up to March 16th, bringing total airline deliveries to 62 (plus one for General Electric). Sabena now has the first four of six *Caravelle 6s* on order. Royal Air Maroc has received its *Caravelle 3*, completing the current order for two aircraft. Air France received another *Caravelle 3* in mid-March, bringing total deliveries to the carrier to 25 aircraft.

Military affairs

United States Defense Secretary Robert S. McNamara has announced a reorganization of Air Research and Development Command and Air Materiel Command to improve management and speed up military space programmes, including reconnaissance satellites and space weapons. ARDC Commander Lieutenant-General Bernard A. Schriever is redesignated Commander of the Air Force Systems Command, which will have four divisions: 1) the Ballistic Systems Division, to include elements of ARDC's Ballistic Missile Division, the Air Materiel Command Ballistic Missile Center and the Army Corps of Engineers' Ballistic Missile Office (responsible for construction of missile bases); 2) the Space Systems Division, including other elements of the ARDC and AMC ballistic missile organization; 3) the Aeronautical Systems Division of Wright-Patterson AFB (Dayton, Ohio), and combining Wright Air Development Division and the Aeronautical Systems Center; and 4) the Electronics Systems Division, based at Hanscombe Field, near Boston, combining the AMC electronics systems centre. The reorganization gives the Air Force almost complete control of all military space development projects.

AMC Commander General Samuel G. Anderson becomes head of the new Air Force Logistics Command.

●

North American Air Defense Command is forming a space tracking unit designated 1st Aerospace Surveillance and Control Squadron, to be based at Colorado Springs. The new unit will watch for foreign spy-type satellites and potential bomb carriers. In future, Navy and Air Force space surveillance systems will report direct to this unit instead of going through their own service channel.

●

The United States Air Force had 18 operational *Atlas* missiles available in above-ground sites at mid-March. Nine new ICBMs at Warren AFB were added to the six already at Warren and three at Vandenberg AFB. Another nine *Atlas* missiles will become operational at Offutt AFB (Omaha, Neb.) early this month.

●

The U.S. Navy has given General Electric's Ordnance Department a $20 million contract for advanced fire control systems for the *Polaris* FBM submarine, bringing total Navy awards for design and manufacture of the system to over $52 million. Designated MK84, the advanced system will provide improved operational capability for the FBM weapons system by the extensive utilization of new digital computing techniques.

●

The U.S. Army has given Ford Motor Co. a $5,361,619 contract for continued research and development of the *Shillelagh*, a lightweight guided missile designed for close support for ground troops.

A configuration conference on the Lockheed C-141 strategic airlift transport for MATS (SS-476L/SOR.182 — cf. "*What's in the Air?*" this issue) is expected this month. Final details of configuration and performance will not be known until these talks have been concluded but the design will generally conform to Lockheed's GL 207-42 proposal. Freight compartment dimensions will be 9 ft high, 10 ft wide and overall length of approximately 70 ft. The USAF is expected to specify Pratt & Whitney front-fan engines to power the C-141.

●

The United States Air Force has brought the third Sperry Gyroscope FPS-35 long-range search radar into operation at Benton, Pa., to serve the New York Air Defense Sector. Two earlier installations are in operation at Thomasville, Ala. and Montauc Point, N.Y.

●

The British Royal Navy has now ordered a trial batch of Martin *Bullpup* air-to-surface missiles. The weapons are to be tested by the Fleet Air Arm this month in *Scimitars*, *Sea Vixens* and *Buccaneers*. The Royal Air Force is still reportedly interested in the *Bullpup* and may eventually place an order.

Aircraft

Fokker has announced the following increase in payload/range performance, or decrease in operating cost per ton- and per seat-mile for its various versions of the *Friendship*. The improvements are expected to be officially certificated by the middle of this year. For all *Friendship* versions powered by the Rolls-Royce *Dart RDa.6* Mk.511, the all-up weight will increase from the present 37,500 lb to 39,000 lb; for all *Friendships* powered by the Rolls-Royce *Dart RDa.7* Mk.528, the all-up weight will increase from 37,500 lb to 42,000 lb. In terms of payload/range, these improvements will represent, for the F.27 versions accommodating 40, 44 and 48 passengers: a 40 passenger load of 8,700 lb can be carried over 1,100 n.m., block time 4 h 42 min, at direct operating costs per seat/n.m. of U.S. cents 1.33; a 44 passenger load of 9,400 lb over 1,080 n.m., block time 4 h 37 min, at direct operating costs per seat/n.m. of 1,21 cents; a 48 passenger load of 10,300 lb over 960 n.m., block time 4 h 9 min, at direct operating costs per seat/n.m. of 1.12 cents.

●

Potez has published the following technical data on the CM.191 four-seat tourer, a derivative of the *Magister* jet trainer developed jointly by Potez and Heinkel. The aircraft, which is powered by two Turboméca *Marboré VIs*, each with a thrust of 1,060 lb, has a wing span of 39.4 ft, a length of 32.8 ft and a wing area of 198.1 sq. ft. Weight equipped 4,520 lb; all-up weight 8,135 lb normal or 8,995 lb with overload. Maximum speed 380 knots; cruising speed 360 knots; most economical cruising speed 265 knots; rate or climb 2,950 ft/min; service ceiling 40,000 ft; range 810 n.m., or 1,080 n.m. with two auxiliary tanks.

●

Victa Consolidated Industries Ltd., Milperra, N.S.W., Australia, has issued further details of the R.2 four-seat touring aircraft, which it intends to produce in large numbers. A first prototype is already complete and will shortly begin flight tests. The R.2 is powered by a 180 h.p. Lycoming O-360-A1A engine with a McCauley variable pitch propeller. Span is given as 32 ft, length 21.6 ft and wing area 132 sq. ft. Weight equipped 1,190 lb; all-up weight 2,250 lb. With two persons aboard, the aircraft is fully aerobatic. Flight performance: maximum sea level speed approximately 165 knots; cruising speed approximately 150 knots; maximum range approximately 640 n.m.; max. sea level rate of climb 1,160 ft/min — 820 ft/min at 5,000 ft; service ceiling approx. 16,600 ft; take-off roll 180 to 220 yd.

●

The U.S. Navy Board of Inspection and Survey has begun testing the Sikorsky HSS-2 amphibious helicopter. These are the final tests prior to fleet delivery, and are taking place at the Naval Air Test Center, Patuxent River, Maryland, to which seven HSS-2s have been delivered. Powerplant of the HSS-2 consists of two General Electric T58-8 turbines of 1,250 s.h.p. maximum rating and 1,050 s.h.p. normal rated power each. Specifications for the HSS-2 are: diameter of main rotor 62 ft; fuselage length 54 ft 9 in.; overall length 72 ft 6 in.; empty weight 10,854 lb; gross weight 17,300 lb; fuel capacity 690 U.S.gal. Performance: top speed at sea level approximately 130 knots; best rate of climb at sea level 1,780 ft/min; range with maximum fuel including 10% reserves at cruising speed is approximately 500 n.m.

●

Bell Aerosystems Company has demonstrated a new three-passenger air cushion vehicle, powered by a 65 h.p. motor car engine. The vehicle has a central fan, is 18 ft long, weighs 2,000 lb and can travel at a level speed of about 15 m.p.h. with full payload. Bell stresses that the vehicle is purely an experimental one to prepare for an extension of the company's activities in the field of ground effects machines.

Corrections

In the description of the Del Mar RADOP towed targets which appeared on page 222 of *Interavia* No.2/1961, it was erroneously stated that Dornier had sales rights for the German Federal Republic, Scandinavia and Switzerland. The exclusive agent for Del Mar in Denmark, Finland, Norway and Sweden is Swedish Air Service Ltd., Arsenalsgatan 4, Stockholm C, who also has sole sales rights for Del Mar equipment in Israel and Ethiopia. Readers are asked to forgive this error and to note the correct name and address.

The Editors of the English edition of *Interavia* Review have to apologize for an error in the article entitled "Cold Front in International Air Traffic Negotiations" (*Interavia*, No. 1/1961, p. 111) which contained the following statement: "In an article which appeared in mid-November 1960, IATA attempted to account for the breakdown of the American-Scandinavian negotiations..." The correct initials should be ITA (Institut du Transport Aérien); IATA (International Air Transport Association) has nothing to do with bilateral negotiations and is not allowed to express, or even possess, opinions on such matters.

Photo credits : Front cover : manufacturers ; pp. 443-445 : Aéroport de Paris (4), Interavia files (1) ; Interavia (1) ; pp. 446-448 : Aéroport de Paris (6) ; pp. 449-450 : Aéroport de Paris (3) ; pp. 452-453 : Aéroport de Paris (2) ; pp. 454-457 : Aéroport de Paris (4) ; CSF (5), Interavia drawing (1) ; p. 458 : Aéroport de Paris (4) ; pp. 463-464 : USAF (3) ; pp. 465-468 : manufacturers (11), Interavia drawing (1) ; pp. 469-470 : manufacturers (3) ; pp. 479-484 : manufacturers (21), Interavia drawings (2) ; p. 485 : U.S. Navy (2), Interavia drawing (1) ; pp. 486-488 : manufacturers (6) ; p. 489 : manufacturers (3) ; pp. 490-493 : manufacturers (12) ; p. 494 : manufacturers (2), NASA (1) ; pp. 499-500 : manufacturers (3), Interavia drawing (1) ; pp. 501-502 : manufacturers (8).

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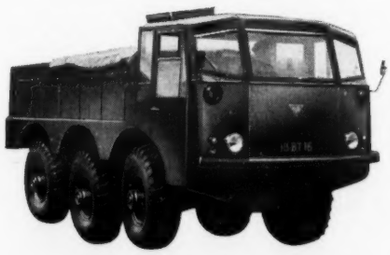
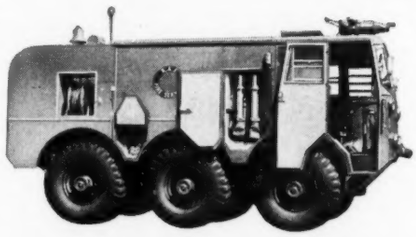


STALWART
CARGO
CARRIER



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The Ampex FR-700
wideband magnetic tape system
can function as a universal predetection telemetry recorder. This ground-based companion to the airborne AR-300 both records and reproduces, and will play back tapes recorded on any Ampex AR-300. Bandwidth data is FM recorded using a 6 megacycle carrier. Rotating magnetic heads record transversely, one wideband channel for one hour at 12½ ips., or two wideband channels simultaneously for one-half hour at 25 ips. Input power is 1200 watts at 50 or 60 cycles. For specifications write to Ampex Great Britain Limited, Arkwright Road, Reading, Berks., England. AMPEX

INTERAVIA AIR LETTER reports...

(Contd. from page 408)

Aircraft and Engines

The Potez 840 has now been completed at Toulouse, where it has been transported from Argenteuil. The first prototype, which will shortly begin flight tests, has been built in a bare twelve months, and a second prototype is under construction at Argenteuil. Designed primarily for domestic services, the Potez 840 is powered by four Turboméca *Astazous*. A number of airlines are examining the characteristics of the aircraft, which will be exhibited at the Paris Air Show at Le Bourget, together with the Potez-Heinkel 191, a four-seat, twin-jet aircraft being built in Germany.

●

The G.A.M. Dassault Mirage IV-01 Mach 2 bomber (two SNECMA *Atar 9* jets) has resumed flight tests, following a number of modifications. The silhouette of the aircraft has undergone a single modification: the addition of a plastic ventral radome.

●

Testing of the Nord-Aviation Griffon 02 research aircraft by test pilots André Turcat and Armand Jacquet has now been extended to include high-speed tests. The present series of tests will serve mainly to investigate the properties of materials (such as friction heating of the skin, cabin cooling problems, electronic equipment, etc.).

●

The U.S. Federal Aviation Agency has issued type certification for the new Model 185 Cessna *Skywagon* six-seat aircraft, fitted with a 260 h.p. Continental IO-470-F engine.

●

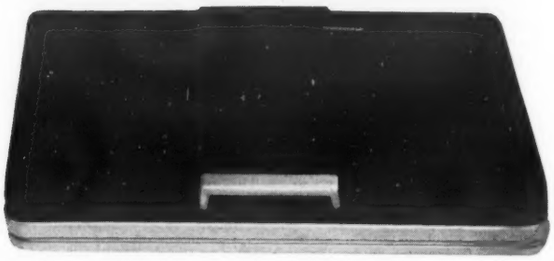
The Federal Aviation Agency has approved the use of a "fifth pod" to transport a spare engine under the wing of the Douglas DC-8 airliner (very similar to the *Pod-Pak* used by Qantas Empire Airways on its Boeing 707s). The DC-8 pod consists of an aluminium and plastic fairing for enclosing a complete engine assembly, and the pylon for attaching the spare powerplant between the fuselage and No. 2 engine. When dismantled, the 15-piece fairing and pylon kit can be carried in the cargo hold. Provisions for carrying the jet engine externally have been made on DC-8s of Pan American, United, KLM, Panagra, SAS, Swissair, TCA, Alitalia, Northwest, UAT and Japan Air Lines.

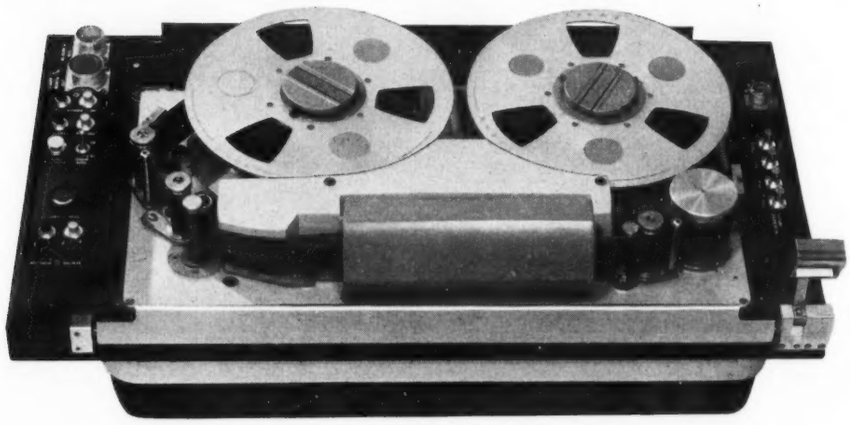
●

The prototype of the RF 1 touring aircraft, built by Rhein-Flugzeugbau GmbH, Krefeld-Uerdingen, has been completed. The RF 1, which will probably be exhibited at the Paris Air Show, is characrerized by a number of revolutionary design features. The ducted propeller, semi-annular wing and jet deflection device are expected to provide a marked increase in lift and thrust. The automatic centrifugal clutch and freewheel enable the two wing-mounted 250 h.p. Lycoming engines to operate separately. The RF 1's undercarriage is electrically retractable. Two doors, with integral stairs, which run the full length of the main cabin, open downwards and enable the aircraft to be used as a freighter or an ambulance for four stretcher cases. Main dimensions: length 42.9 ft; height 12.6 ft; span with wing-tip tanks 46.2 ft; Weights: weight equipped 3,970 lb; useful load 1,980 lb; all-up weight 5,950 lb. The aircraft can transport four people, including pilot. Normal fuel capacity 2×40 Imp. gal.; external tanks provide an additional 2×35 Imp. gal. Design performance: range with external tanks plus 30 min reserves 810 n.m.; maximum speed 160 knots; cruising speed 140 knots; service ceiling 20,300 ft at 5,950 lb all-up weight; take-off distance 490 ft at 5,950 lb.

●

The Bell 204B helicopter, commercial version of the HU-1 *Iroquois*, is now available on the world market, according to a company statement (the 204B is produced under licence in Italy by Costruzioni Aeronautiche Giovanni Agusta of Cascina Costa, Gallarate). Deliveries of U.S.-built Bell 204Bs will probably begin in late 1961 at a price of about $285,000 including powerplant (one 1,000 s.h.p. Lycoming T53-L-9). With this power, the Bell 204B attains a top speed of 147 m.p.h.; rate of climb is said to be 2,660 ft/min; hovering ceiling in ground effect on a standard day is 17,600 ft; range is 260 miles. Component replacement times for the Model 204B are as follows: engine, complete 20 min; transmission 40 min; main rotor and hub 20 min; landing skids 20 min; oil cooler 30 min; main generator 10 min; and battery 5 min.





The Ampex AR-300 airborne magnetic tape recorder
offers 16 times the frequency response of existing wideband equipment. New applications in video bandwidth recording such as radar tracking and reconnaissance, simulation and wideband communications monitoring, are now practical because the AR-300 – and its ground-based companion, the FR-700 – employs rotating magnetic heads... a principle pioneered by Ampex and now in use by more than 650 VIDEOTAPE* Television Recorders throughout the world. Two channels of wideband information can be captured over a data spectrum from 10 cps to four megacycles, ±3 db. Simultaneously, two auxiliary information channels, with frequency response from 200 cps to 15 Kc, are recorded linearly along the edge of the tape. Solid-state components and advanced packaging techniques case-shock mounted provide a recording system that displaces only 3½ cu. ft., weighs less than 150 lbs. To obtain a highly accurate time-base relationship, tape is pre-heated prior to recording. A heat exchanger maintains constant ambient, insuring reliable operation of the AR-300 under extreme environmental conditions. For specifications write to Ampex Great Britain Limited, Arkwright Road, Reading, Berks., England. AMPEX

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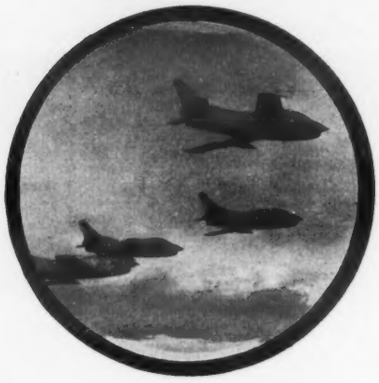
See Ampex Instrumentation Tape Recorders at MESUCORA, May 9-17, Paris.

FIAT G91T

patrol in flight



flight simulator

departure on a strike mission

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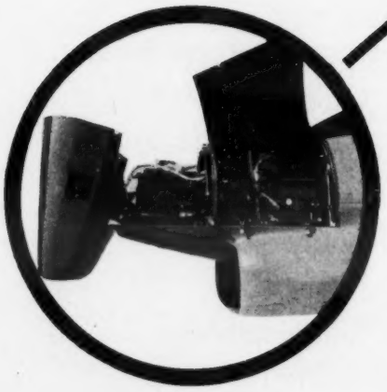

observation

offensive armament

armed reconnaissance

Fiat - Divisione Aviazione - Corso G. Agnelli 200 - Turin, Italy

CSF radar for air traffic control

RAPY

CSF long-range radars, which have already been chosen to equip Area Control Centres in France (Orly, Aix-en-Provence, Bordeaux and Lyons), Indonesia (Soerabaja) and the Union of South Africa (Capetown), have now been selected by the Australian Government for Sydney and Adelaide.

These radars fully comply with ICAO specifications defining the new radar coverage which has become indispensable since the placing in service of jet airliners. The CSF systems consist of two 2 megawatt transmitter-receivers working in diversity, which are fitted with highly effective devices for eliminating static targets and atmospheric clutter and ensure an exceptional reliability of detection at ranges of up to 300 miles.

Similar radars, but with different range characteristics for the surveillance of more restricted areas, are also supplied by CSF for the coverage of airport approach zones (Orly, Le Bourget, etc.).

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STC SA.10

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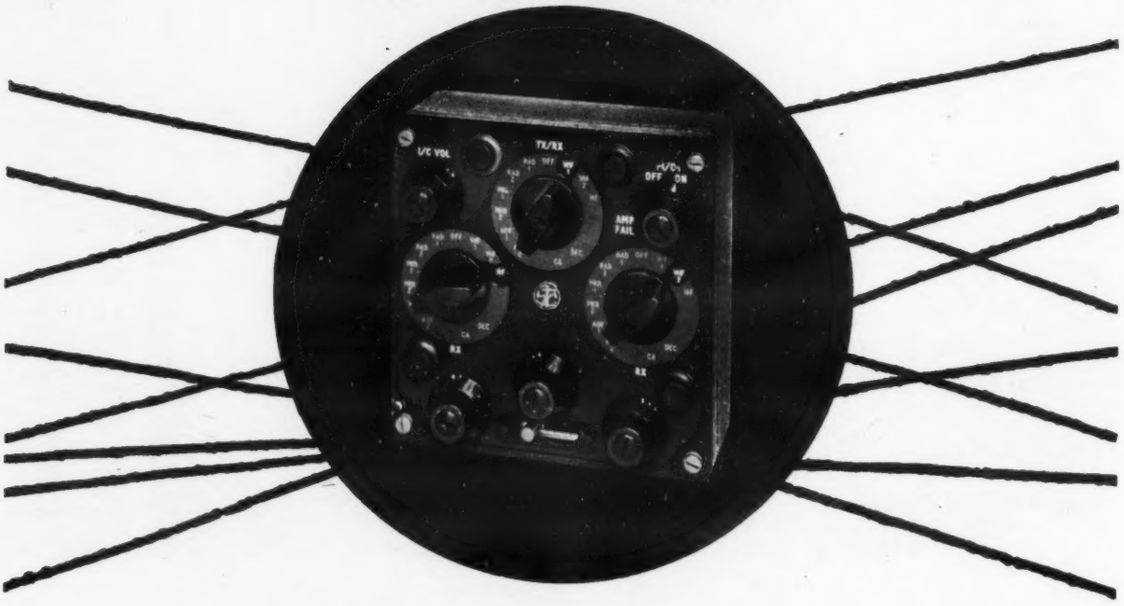

- *Designed for Extreme Reliability.*
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- *Main unit designed to ARINC characteristic 404.*
- *Full M of A and FAA type approval.*
- *A cockpit loudspeaker and a transistorised amplifier unit type SA.11 are available for use in conjunction with this equipment.*

The SA.10 equipment is designed to permit intercommunication between members of the flight crew, cabin staff and, where required, between the flight crew and the ground engineer. It comprises an amplifier which can be used with a maximum number of five flight crew station boxes, one of which is shown above, and a junction box for interconnection purposes

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VERDAN

The advanced digital computer for use in military systems is now available

Today's advanced real-time systems require equally advanced computers to provide them with split-second problem-solving and decision-making. One of America's most advanced computers is Verdan, built by Autonetics. Verdan units have proven themselves in U. S. systems such as the Polaris submarines, the Hound Dog missiles, and the A3J Vigilante aircraft.

Verdan is a solid-state computer. It weighs only 82 pounds, measures only 1.4 cu. ft., requires a nominal 300 watts of electricity, and has *proven* reliability. It would take a room full of equipment in a comparable ground-based computer to match its performance.

An especially important feature of Verdan is its versatility. It operates simultaneously as a general-purpose computer and as a digital differential analyzer while generating and accepting digital and analogue outputs and inputs. Verdan's solutions may be displayed in a neon tube register, punched on paper tape, or typed using an electric typewriter.

Verdan accepts digital information on punched paper tape at a rate of 800 five-bit characters a second with parity check. Digital differential analyzer solutions are completed 100 times a second. Storage capacity is 1664 words in 13 channels on a magnetic disk. This includes the memory requirements of 128 digital differential analyzer integrators. Special self-checking features insure quick location of any possible malfunctions.

Verdan is the most advanced field-proven computation center available for bombing navigation, flight and fire control, data processing, automatic ground checkout, and as a complete missile system simulator.

Verdan is now available in Europe. Designer and producer is Autonetics—an international leader in electronic and electromechanical systems.

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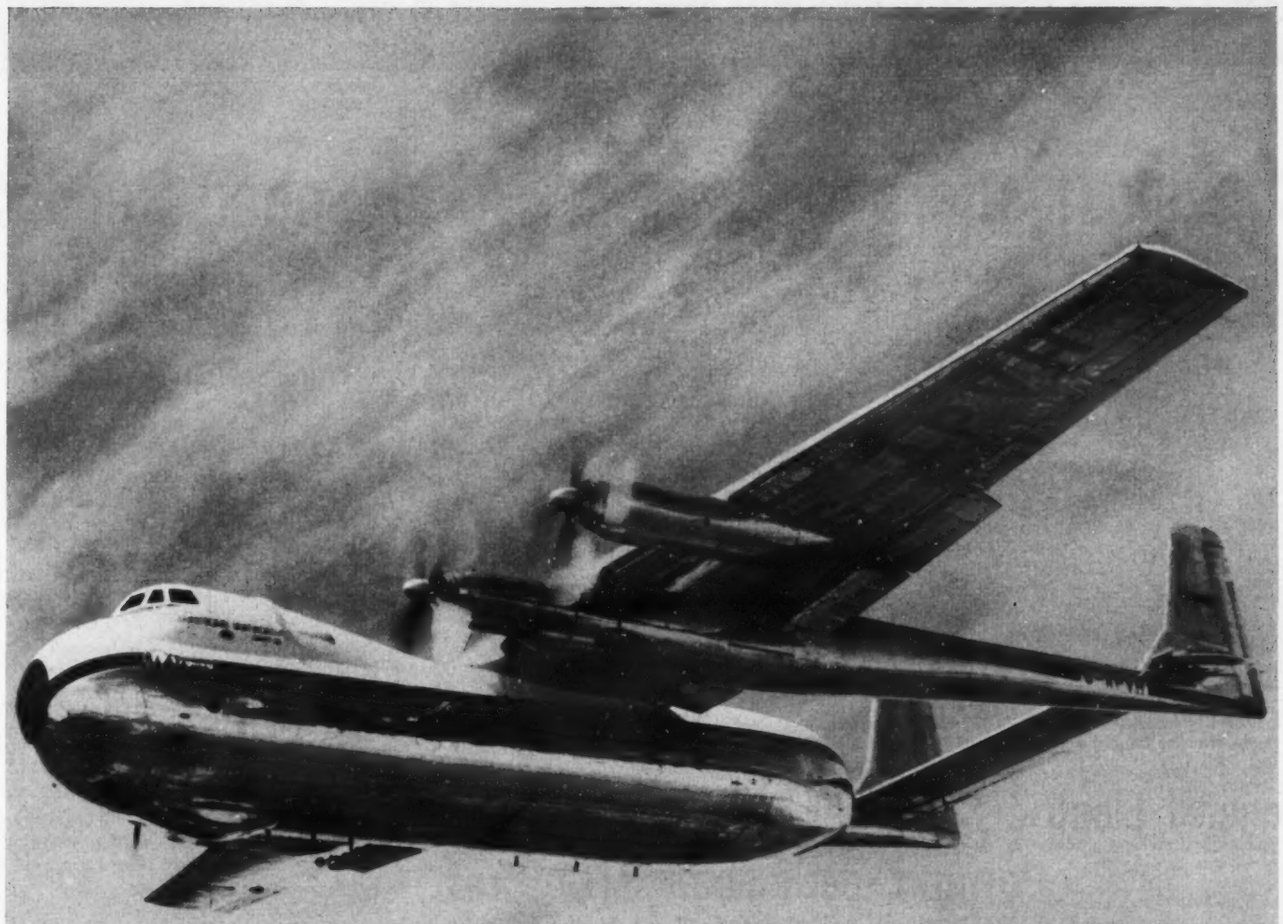


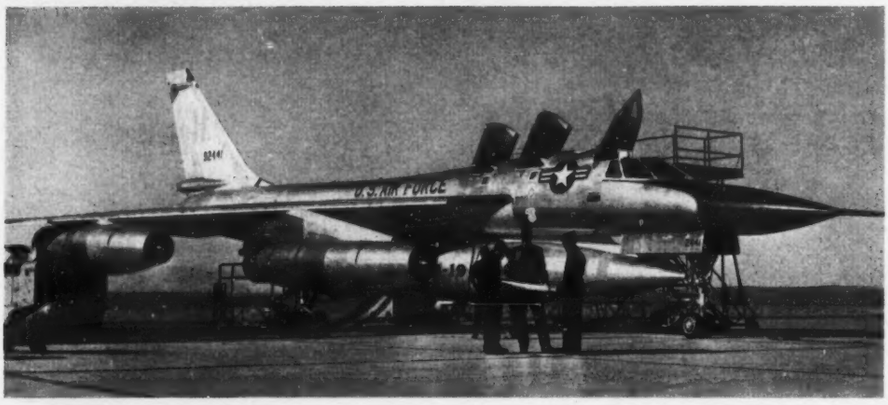
TODAY'S
ECONOMICAL
AIR FREIGHTER

ARGOSY

HAWKER SIDDELEY AVIATION 32 Duke Street, St. James's, London, S.W. 1.

Flight Propulsion

Convair Hustlers Smash Six World Speed Records



One of SAC's record-breaking B-58 flight crews checks final flight plan prior to takeoff. This J79-powered Hustler logged a top speed of 1430 mph during its run

Log Top Speed of 1430 mph

EDWARDS AFB, Cal.—Six world speed records, five of them Russian-held, were nearly doubled here recently by two Convair B-58 Hustlers from SAC's 43rd Bomb Wing.

The Hustlers were powered by General Electric J79 turbojet engines, which have helped set 18 world speed, altitude and payload records in little more than a year.

A B-58 piloted by Maj. H. J. Deutschendorf averaged 1061.8 mph while carrying a 2000 kg (kilogram) payload over a 2000 kilometer closed course. The record claim, which is over 450 mph faster than that previously held by a Russian Tu-104, was also entered for the no-payload and 1000 kg payload categories.

Two days later another B-58 swept over a 1000 km course at an average speed of 1248.7 mph. Records were claimed for the same three payloads. The Hustler, piloted by Maj. H. E. Confer, logged a top speed of 1430 mph during the run.

The previous 1000 km record was held by an Air Force F-101 Voodoo in the no-payload class, with 700.5 mph, and by Russia (639 mph), in the 1000 and 2000 kg categories.

General Electric Small Jet Engines Power Experimental VTOL Craft

MOFFET AFB, Calif.—A variety of vertical takeoff and landing aircraft are now in development with versatile General Electric small gas turbine engines as the power source.

A lift-fan concept is being evaluated at Moffet Air Force Base, where a dry J85/lift-fan combination is undergoing wind-tunnel testing. A J85-powered lift fan recently completed more than 100 hours running time.

In another program, diverted thrust from a J85 turbojet powers the Bell X-14, which NASA is using to test the feasibility of advanced propulsion and control techniques for VTOL and other future aircraft. The X-14 is currently in flight status.

General Electric's T58 turboshaft engine is the powerplant for two experimental VTOL aircraft. The Fairchild M224, which began flying late last year, attains VTOL capability from deflected slip stream on the wing's trailing edge. Kaman's K-16, soon scheduled for flight test, combines semi-tilt wing, deflector flaps, and cyclic-pitch propellers.

G.E. is also making available the flight-qualified T64, a turboprop/turboshaft engine whose low SFC approaches that of reciprocating engines. Designed to operate continuously from 45 degrees below to 100 degrees above the horizontal, the T64 is especially suited for tilt-wing VTOL applications.

Use the coupon if you would like additional free information on G.E.'s J85, T58, T64 and CT58 engines.

B-58 Awarded Thompson Trophy

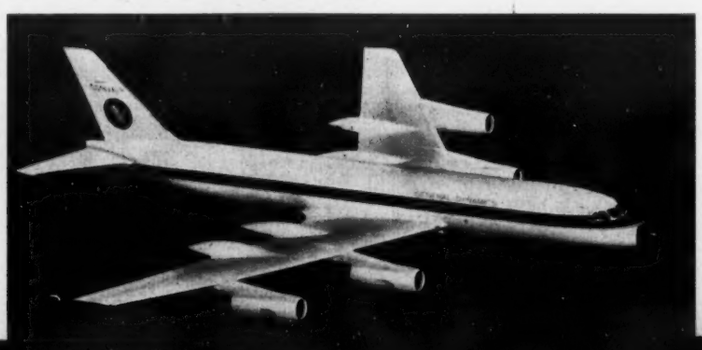
WASHINGTON, D.C.—The Convair B-58 piloted by Maj. H. E. Confer was awarded the coveted Thompson Trophy in late February for its record-breaking closed course speed of 1430 mph.

It is the first time in aviation history that the trophy has been won by a heavy bomber. The award is presented annually by the Air Foundation of Cleveland.

The CJ-805 Aloft: 880 Nears First Anniversary; 990 and C

CONVAIR 880—Fastest jetliner now in commercial service, the Convair 880 will enter its second year of operation on May 15. The CJ-805-3 powered transport is now flying with Delta, Northeast, and Trans World Airlines, and will "go international" in mid-year when Japan Air Lines inaugurates 880 jet service linking Tokyo with other major Far East cities.

CONVAIR 990—The 640-mph jet flew for the first time on January 24, and is being flight tested prior to scheduled service with AAL, REAL, Swissair, and SAS later this year. Four G-E CJ-805-23 aft-fanengines power the 990, whose maiden voyage was described by Convair Chief Test Pilot Don Germeraad as, "The cleanest I've had in six first flights."



NEWS

A report about progress in research and products from the Flight Propulsion Division of the General Electric Company

SAC Hustlers Complete Six Months of Operation

CARSWELL AFB, Tex.—SAC's 43rd Bomb Wing—the Air Force's first operational group of Convair B-58 Hustlers—has completed its first six months of operational duty here.

During more than 4000 hours of engine flight time, reliability of the Hustlers' J79-5B turbojets was evidenced by a rate of approximately 400 hours between unscheduled engine removals for all causes.

Engine flight time for all phases of the Air Force's and Convair's B-58 program is currently over 25,000 hours. Four General Electric J79's power the Mach 2 bomber with a combined thrust of over 62,000 pounds.

First Year of Flight Testing Confirms Aft-fan Principle

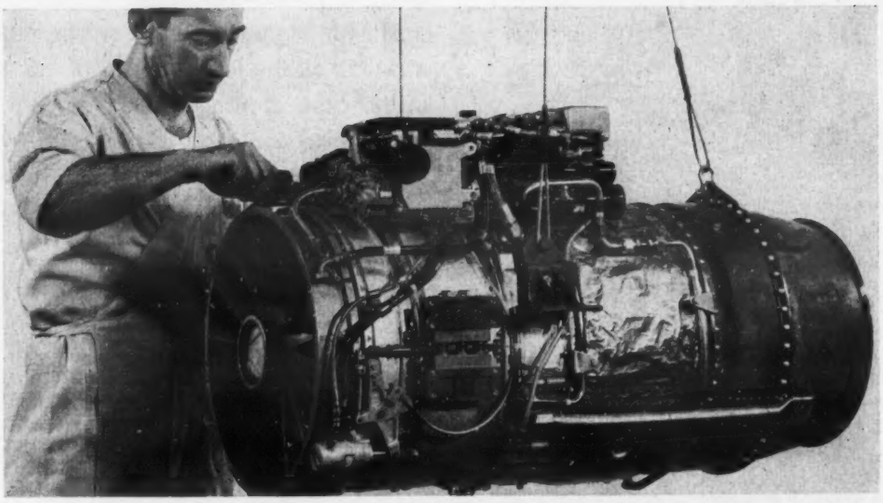
CINCINNATI, Ohio— "General Electric's first year of turbo-fan flight testing has proven beyond a doubt the soundness and practicability of the aft-fan principle," according to G-E Commercial Engine Operation Manager Neil Burgess.

His comment was occasioned on the first anniversary of American turbo-fan flight last February 19. On that day a year ago a G.E.-leased RB-66 flew aloft powered by two CJ-805-23s.

"The engines," reported Mr. Burgess, "have been operated over a complete range of altitudes and air speeds, under severe distorted inlet conditions, and with two entirely new nacelle designs. The fan has in no way compromised the good throttle response characteristics of the engine.

"In all cases," he said, "we have been completely satisfied with the engine operating characteristics. In particular, the low noise levels of the engine are outstanding."

During this period, two other aircraft—the Convair 990 and G.E.'s Caravelle VII—also initiated flight test programs using G-E aft-fan engines.



G.E.'s modified 10-to-1-ratio J85 will be ideal for VTOL, STOL, and helicopter boost power.

J85 Modified to Produce 10 to 1 Power Ratio

LYNN, Mass.—General Electric's J85 turbojet engine can now be modified to produce a thrust-to-weight ratio of more than 10 to 1.

Production J85 engines currently entering service with the Air Force deliver a specified 7.6 to 1 ratio, the highest of any military production jet powerplant.

The 10 to 1 power ratio makes the modified J85 an ideal engine to provide auxiliary power for VTOL and STOL aircraft. Here its primary use would be to provide boost power for takeoff and landing operations.

Adaptation of the modified engine to helicopters, where it could substantially augment cruise power and lift power, is also a possibility.

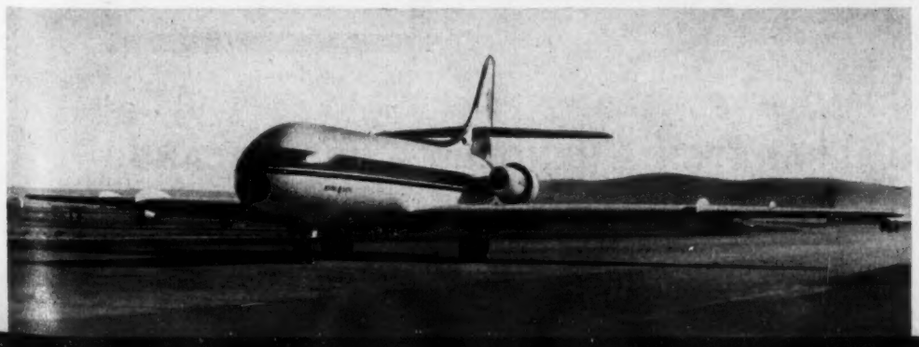
Boosting the J85's power ratio to 10 to 1 was accomplished by removing accessories—reducing engine weight from 325 pounds to less than 300—and by increasing engine speed and temperature. Over-all dimensions are similar to those of the J85-7.

A dry commercial version of the J85—the CJ610—develops 2850 pounds of thrust, weighs only 355 pounds.

A growth version of the commercial aft-fan engine, the MF239C-3, is being offered for the MATS SS467 cargo transport. It will develop up to 23,800 pounds of takeoff thrust, as compared with 16,100 for the CJ-805-23.

Caravelle Flight Tests Progress Well

SUD/DOUGLAS CARAVELLE VII—Now entering its fourth month of intensive flight testing after conversion to General Electric CJ-805-23 aft-fan turbojet engines, G.E.'s Caravelle VII is currently in the midst of a heavily instrumented flight program marked for completion this spring. Tests have included in-flight noise measurements, duct inlet design confirmations, and thrust reverser trials. Performance to date, including noise level and short-runway prowess, has been highly favorable.



FOR MORE INFORMATION

If you would like free brochures on these or other G-E flight propulsion products, just clip and send this coupon.

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- GED-4260 "MF239-C Aft-fan Turbojet"
- GED-4095 "J85 Turbojet"
- GED-3985, "The T58 Turboshaft Engine"
- SAE-110A, "The T64 Turboprop/Turboshaft"
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Satco comprises the ground equipment to predict, coordinate, check and display the movements of air traffic en route and in terminal areas. It provides an extremely rapid method of calculating flight paths, for assessing potential conflicts and for coordination between Area Control Centres. Special features are included for military / civil coordination and for the control of jet-powered traffic.

The system has been ordered by The Netherlands Government and the first phase is now on operational test.

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***LIGHTERAGE BY AIR*—Demonstrating its versatility as a cargo carrier, Sikorsky's S-60 *Skycrane* recently lifted a cargo container from the hold of a ship at sea; minutes later placed it in a truck ashore. The S-60 can carry five tons. The next *Skycrane*, the turbine-powered S-64, will lift up to ten tons. Future designs will carry up to 40 tons. Transporting loads by cargo hook or complete units in pre-loaded pods, the *Skycrane* is easily adapted to a multiplicity of military and industrial uses.**

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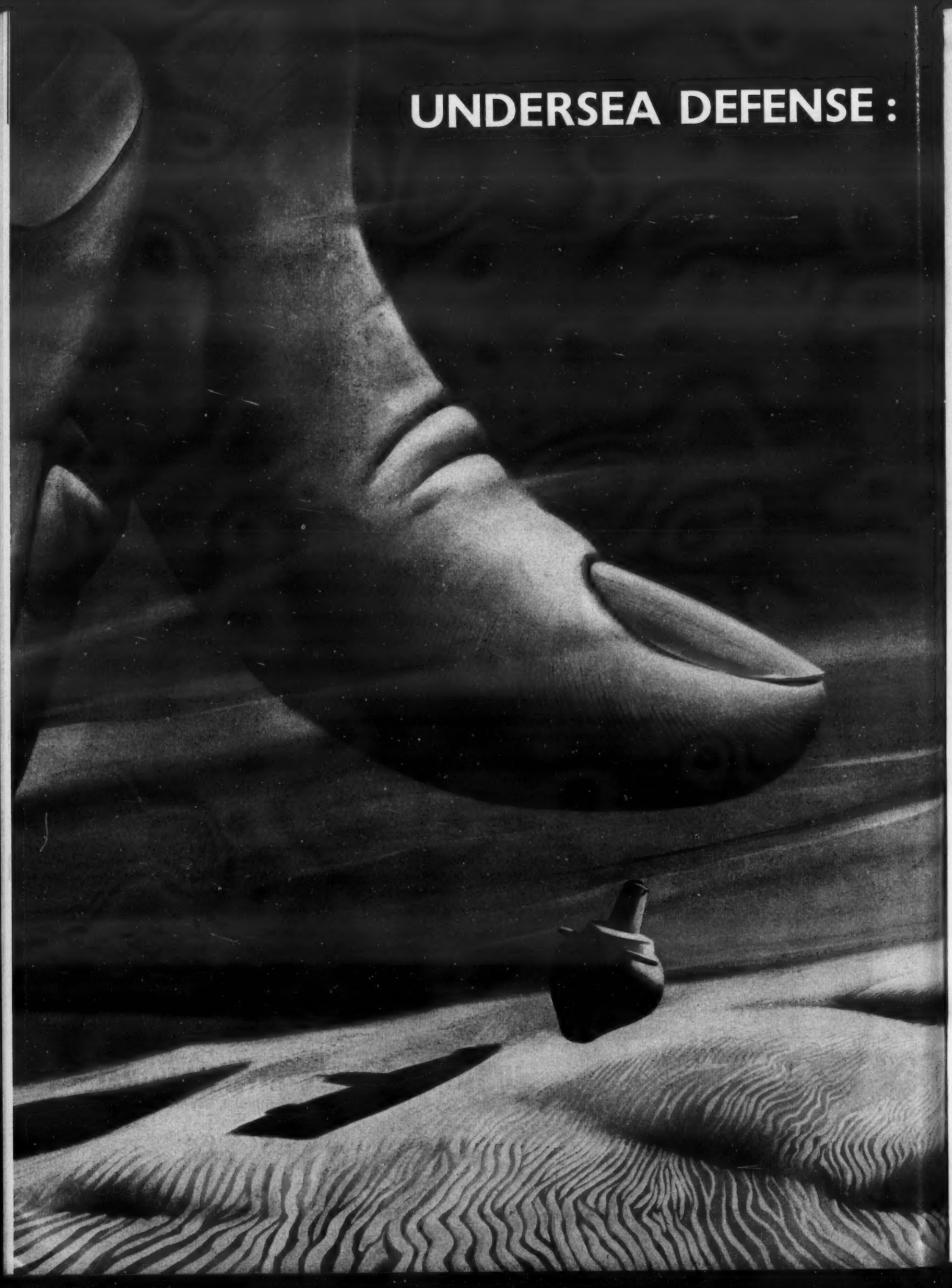

UNDERSEA DEFENSE :

FROM TALENTS TO HARDWARE

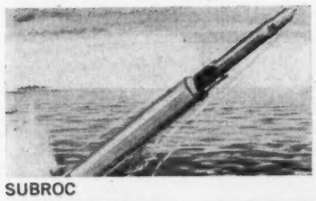
LOOK TO GENERAL PRECISION FOR DEVELOPMENT, PRODUCTION AND SYSTEMS MANAGEMENT

The talents and capabilities of the four divisions of General Precision, Inc., are heavily represented in the Navy's latest weapons systems, as well as in space-age hardware of all categories. The divisions are responsible for some system, subsystem or component on virtually every missile, rocket, aircraft and spacecraft now in operation or development, including all of the Navy's antisubmarine warfare equipment on surface ships and submarines.

To make these broad capabilities available to the fullest of their combined potential, General Precision, Inc., has consolidated its four divisions for the systems management of major new undersea defense projects and other important weapons and space systems.

A major undersea weapons program can now draw upon more than 2½ million square feet of combined General Precision floor space and over 16,000 General Precision employees, including 4,500 scientists, engineers and technicians.

This combination of talents and facilities, backed by the corporate financial resources of General Precision, Inc., makes it possible to develop, produce and manage an undersea defense system as an integrated package.



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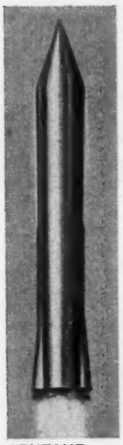
ASROC

TALOS



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If the time has come when a company-owned aircraft is a necessity, consider the experience of de Havilland. Except during the war they have always built executive aircraft. The lessons of four decades and more are embodied in the new Dove.

With increased power, improved performance, superior equipment entirely suitable for all-weather operation, the new Dove 8 is the best aircraft in its category.

The same may be said of the larger four-engined Heron.

de Havilland built and de Havilland powered, with two Gipsy Queen 400 h.p. engines and de Havilland propellers, the Dove 8 executive carries up to six passengers and two crew on practical stages of about 600 miles (*960 km*), at 210 miles (*336 km*) an hour. Doves and Herons are flown and serviced the world over.

HAWKER SIDDELEY AVIATION GROUP

Freight Tariff War over the North Atlantic?

By dint of great effort, IATA has in the past two years always succeeded in averting the worst at the last moment and arriving at a system of rates acceptable to all. In mid-October, 1959, after the abortive Honolulu Traffic Conference, it almost seemed as if the regulation of fares by IATA, and with it IATA itself, had come to an end. But early in 1960, at Paris, ruffled tempers were smoothed, and by autumn, when the airlines met in Cannes, the sun was shining again—albeit somewhat feebly. Agreement in principle had been reached on all tariff items except North Atlantic freight rates, which were to be regulated by a special conference to be held at Paris early in 1961.

This special conference, which sat from January 23rd to February 10th under the chairmanship of Hans Aeppli, Deputy Manager of the Swissair Traffic and Sales Department, and was attended by representatives of 35 airlines, ended in a declaration of war.

Unless a miracle occurs, there will be no standardized air freight rates across the North Atlantic after April 10th this year.* The eighteen North Atlantic freight operators can quote what freight rates they think fit—subject to the approval of the governments concerned—and do everything in their power to outbid their competitors by a few cents per kilo.

That the air freight problem urgently requires a new solution is beyond all doubt. The first orders have already been placed for the large freighters which will make it possible to drastically reduce operating costs (a number of estimates have set future operating costs at one third of those prevailing today). It was therefore to be expected that the airlines, and particularly those operating across the Atlantic, would examine freight tariffs critically. Nonetheless, it is surprising that this examination has led to a complete abandonment of current freight rate agreements.

Two reasons underlie the jettisoning of the IATA freight rates: their complicated structure and high level, and the "abhorrence of a void," the fear of operating across the Atlantic with half-empty passenger aircraft.

All concerned have long been agreed that rates must be lowered and that the IATA system is far too complicated. Moreover, the airlines have received repeated assurances from a number of quarters—freight aircraft manufacturers, the Federal Aviation Agency and transport experts—that a reduction in freight rates would inevitably lead to a considerable increase in the volume of freight carried. One optimistic estimate even went as far as to say that if rates were halved the volume of freight would increase fivefold, such a drastic reduction depending, however, on the availability of economic pure freight aircraft.

* The North Atlantic operators have since agreed to maintain the existing rates until June 30th.

It was also clear that the air freight business needed a powerful shot in the arm, particularly on the North Atlantic. For since the larger jet airliners were placed in service, passenger load factors have shown a marked decline. Although there were delays in the deliveries of DC-8s, so that the full effect of the rise in capacity had not yet made itself felt in 1960, the number of seats offered across the Atlantic rose from 2,071,041 in 1959 to 2,740,648 in 1960, with an estimated increase to some 4 million for 1961. Air transport circles fear that the seat load factor, which declined from 66% in 1959 to 64.2% in 1960, may drop as low as 50%.

Nor should it be overlooked that the placing in service of jet airliners not only involves increased seating capacity, but also a sharp rise in the freight volume offered. As Hans Aeppli stated, the increase in volume for 1961 and 1962 will be 27%. It is therefore understandable that all Atlantic operators are most anxious to see their aircraft freight holds filled. To achieve this, they say, it is not enough merely to improve customer service and advertising; rates must be drastically reduced.

*

Thus far, all who attended the Paris Conference were in agreement. The trouble began when the method of lowering the rates was discussed.

The IATA rate system is based on two categories: the General Commodity Rates and the Specific Commodity Rates. The former apply to goods of all kinds and consignments of any weight. The rates are determined on the basis of weight and the distance over which the freight is to be transported, with quantity discounts for consignments weighing upwards of 45 kg, 100 kg, 500 kg, 1,000 kg etc.

Far more complicated are the so-called Specific Commodity Rates, which take account not only of distance and weight, but specify separate basic rates for an enormous variety of goods (watches, medicaments, textiles, foodstuffs, automobiles, agricultural machinery, typewriters, etc.); these rates vary from one route to another. The IATA freight manuals published at regular intervals contain thousands of such items: 187 for London, 126 for Paris, 89 for Geneva, 67 for New York etc. It is therefore not surprising that many airlines and forwarding agents find this system somewhat tedious.

In order to achieve the desired bulk freight business on the North Atlantic, a number of airlines—headed by the Americans—proposed doing away with the Specific Commodity Rates altogether, allowing generous reductions on bulk consignments under the General Commodity Rates.

Other carriers were of the opinion that air transport would lose customers if it completely abolished the current system of freight rate differentiation according to class of goods; the twofold rate system should therefore be retained. The Specific Commodity Rates could, if necessary, be simplified by restricting them to a smaller number of classes of goods and grouping these into larger categories.

The American carriers contended that this would be superfluous. Even if freight rates were determined purely by weight, shippers could still be tempted with further reductions on large consignments (over 7,500 kg).

*

Interavia has refrained from expressing a point of view in this matter, as it feels that there is much to be said on both sides and a theoretical judgment is impossible. Even today, however, it can be safely predicted that the abandonment of universally valid rates will have a number of unpleasant consequences for the airlines and forwarding agents.

For one thing, the freight rates planned vary considerably from one company to another. In certain cases, one even seems justified in asking how far the lowest rates lie below the cost of the transport. The following are some examples of proposed freight rates.

The three American Atlantic carriers, Pan American, Trans World and Seaboard & Western, have reportedly agreed on a common bulk rate, which they have submitted to the U.S. Civil Aeronautics Board for approval. Reductions of up to 63% under the present IATA rates are proposed. On the New York-London route, for instance, the IATA General Commodity Rate for a 45 kg consignment is $94.95, or $2.11 per kg. From mid-April onwards, the same consignment transported by any of the three U.S. carriers will cost $68.40, or $1.52 per kg, representing a decrease of 28 %. For larger quantities, the reductions are far more drastic: 43 % less for 500 kg; 62 % less for 7,500 kg. And on the New York-Paris route the reduction for the latter weight is as much as 63 %.

In order, perhaps, to keep in line with the Europeans, the American carriers did, however, decide on specific rates for 13 categories of goods, which include unmounted jewellery, automobile parts, yarns and fibres, clothing, footwear and television sets.

Of the European carriers, BOAC appears to be the one offering the lowest rates. In a bulletin published on March 20th, it announces reductions on the IATA General Commodity Rates of 32 to 76 % for the London-New York route: $1.90 per kg for consignments of up to 45 kg; $1.52 per kg upwards of 45 kg; $1.05 per kg upwards of 100 kg; $0.88 per kg upwards of 250 kg; $0.77 per kg upwards of 500 kg; $0.67 per kg upwards of 1,000 kg.

INTERNATIONAL MEETINGS AND CONFERENCES

Apr. 6th-14th: Committee on Coordination and Liberalization (COCOLI) of the European Civil Aviation Conference, meeting. Seville.

Apr. 10th-14th: COSPAR International Space Research Meeting. Florence.

Apr. 10th-14th: FAA International Symposium on Aviation Research and Development. Atlantic City, N. J.

Apr. 17th-18th: IATA, 14th Technical Conference. Montreal.

Apr. 17th-19th: AGARD Flight Mechanics Panel. Subject : "VTOL/STOL Aircraft." Paris.

Apr. 17th-28th: International Airport Association, 14th Technical Conference. Montreal.

Apr. 18th: IATA Legal Committee. Paris.

Apr. 18th-20th: Airlines Electronic Engineering Committee, Maintenance Meeting. Atlanta, Ga.

Apr. 18th-20th: Stanford Research Institute, International Symposium on Chemical Reactions in the Lower and Upper Atmosphere. San Francisco, Calif.

Apr. 18th-28th: ICAO, Origin and Destination Statistics Panel, Third Meeting. Paris.

Apr. 20th-21st: Eighteenth Annual Society of the Plastics Industry Western Section Conference. Coronado, Calif.

Apr. 20th-22nd: American Meteorological Society and American Geophysical Union, General Meeting. Washington, D.C.

Apr. 22nd-25th: American Association of Airport Executives, Annual Conference. Colorado Springs, Colo.

Apr. 24th: IATA Ground Handling Advisory Group. Montreal.

Apr. 24th: IATA Data Processing Sub-Committee. Paris.

Apr. 24th-27th: Aerospace Medical Association, 32nd Annual Meeting. Chicago, Ill.

Apr. 25th: IATA Technical Committee Administrative Panel. Montreal.

Apr. 25th: ICAO, Personnel Licensing/ Medical Division. Montreal.

Apr. 26th: IATA Technical Committee. Montreal.

Apr. 26th-28th: American Rocket Society, Liquid Rockets, Propellants and Combustion Conference. Palm Beach, Fla.

Apr. 28th: British Interplanetary Society, Symposium on Liquid Hydrogen as a Rocket Propellant. London.

Apr. 30th-May 4th: Instrument Society of America, Seventh National Aerospace Instrumentation Symposium. Houston, Tex.

Apr. 30th-May 9th: Hanover Fair. Hanover.

May 1st: IATA Clearing House and Revenue Accounting Sub-Committees. London.

May 6th-8th: International Week-End, organized by the Klub der Luftfahrt. Konstanz am Bodensee.

May 7th-12th: Airport Operators Council, Annual Membership Meeting. Miami Beach, Fla.

May 8th-10th: German Rocket and Astronautical Society, Conference on "Space and Europe." Konstanz.

May 8th-10th: Institute of Radio Engineers, 13th Annual National Aeronautical Electronics Conference. Dayton, Ohio.

May 9th-11th: Western Joint Computer Conference and Exhibit. Los Angeles, Calif.

May 9th-17th: MESUCORA — International Exhibition of Measurement, Control, Regulation and Automation. Paris.

In addition, BOAC is introducing specific commodity rates for a large number of categories of goods. These rates are even more favourable for large quantities, e.g.: textiles $0.62 per kg for consignments of 250 kg and over; automobile parts and agricultural machinery $0.59 per kg for consignments of 500 kg and over; porcelain and glassware $0.62 per kg for 250 kg and over etc.

The new rates of KLM, which is the second largest carrier of freight across the North Atlantic (after PanAm), were announced by the airline President, I. A. Aler, at a press conference on March 13th, when he made the following statement: "I deeply regret that the parties were unable to reach any agreement on this point, especially as all carriers agreed in principle about the desirability of a reduction of rates, particularly on the North Atlantic route... There are rumours and indications that some airlines intend to introduce unjustifiably low rates for a small weight per consignment, of such a nature that there cannot be any question of sound commercial operation; if these prove to be true, the open situation will perhaps lead to a rate war. In that case KLM will take appropriate measures in the field of rates to ensure retention of its position in Atlantic air freight transport. In the opinion of KLM such a development is not in the interests of the shippers or of the carriers and agents... In the case of carriers and their agents, their profitability will be more or less seriously affected. A period of confusion lies ahead. It is to be hoped that further consultations within IATA will soon lead to a sound freight rate policy."

In addition, Aler announced the following freight rates for KLM: General rate for Amsterdam-New York $2.99 per kg up to 45 kg; $2.25 per kg for 45 kg and over; $1.41 per kg for 100 kg and over; $1.21 per kg for 250 kg and over; $1.10 for 500 kg and over; $0.99 for 1,000 kg and over; $0.68 for 7,500 kg and over; $0.60 for 10,000 kg and over. There are corresponding reductions in the specific rates.

Air France Commercial Manager Michel de Villeneuve accompanied his statement on freight rates by the following declaration: "Air France has no intention of letting itself be led into irresponsible outbidding. The goods which are traditionally excluded from the General Commodity Rates will continue to be transported at the present rates."

Air France will apply the following general commodity rates: $1.52 per kg for 45 kg and upwards; $1.14 for 100 kg and upwards; $0.72 for 300 kg and upwards; $0.66 for 500 kg and upwards.

The rates established by each carrier will have to be submitted to the appropriate national air transport authority and also to CAB. None of these authorities will, of course, allow other carriers to offer rates lower than those charged by its own national airline, and it is therefore hardly probable, says Villeneuve, that a rate war will really break out. It is, however, certain that a difference of as little as five cents per kg would be enough to drain freight traffic off from one country to another.

Villeneuve was convinced that the struggle to fill freight aircraft this summer would be keen. PanAm is planning 12 flights a week with DC-7Cs, TWA 10 a week with Lockheed 1049s. Lufthansa and KLM announce six freight services a week, Air France, Alitalia Sabena and BOAC two each. Seaboard & Western intends to cross the Atlantic twice a day with CL-44s, offering a capacity of 60 tons each day.

Considerable space has been devoted to these individual declarations, as they indicate that the air freight pattern promises to be somewhat chequered after April 10th. Forwarding agents will be racking their brains over the new freight rates, and the airlines, too, will have their hands full with calculations and with their various applications and petitions to CAB and other air transport authorities, including those of transit States. And it will be some time before their applications are dealt with—for it is hardly to be expected that the authorities will work faster just because of a rate war.

Will the chaotic situation and the possibility of a rate war entail immediate and serious financial risks for the carriers concerned? Hardly. With the exception of Seaboard & Western, all the freight operators continue to regard air freight as a highly profitable, but not absolutely indispensable sideline.

Another question is whether the administrative consequences of a rate war—hundreds of major and minor annoyances and a duplication of tedious work—will not very soon make the North Atlantic operators long for a traffic conference and a generally applicable solution—if, of course, this has not already been found by April 10th.

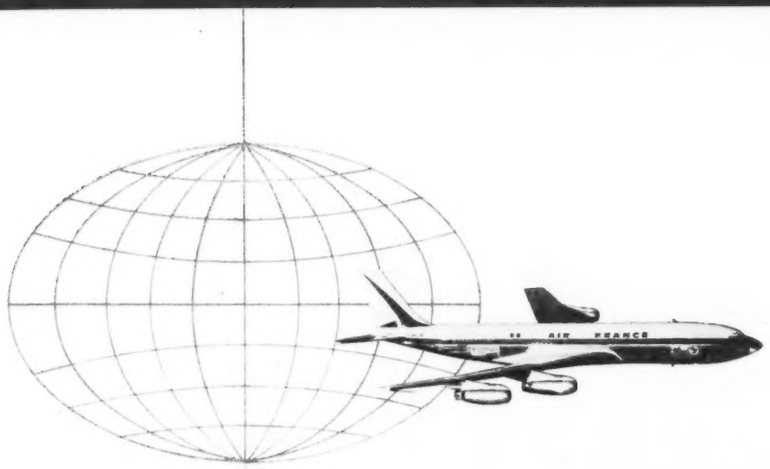
Revenue Tonne-Kilometres Performed by the 18 North Atlantic Carriers on All International Routes in 1959

In millions of tonne-kilometres

	Freight [1]	Passengers [2]	Mail [2]
PAA	143.6	429	50
KLM	83.0	201	12
BOAC	55.0	254	32
Air France	35.8	199	11
Seaboard & Western	33.3	nil	8
SAS	32.7	156	10
Swissair	23.4	88	6
Qantas	22.9	76	14
Sabena	22.2	93	6
Lufthansa	16.3	76	7
TWA	15.5	100	19
Air India	13.2	38	5
Alitalia	11.8	81	5
TCA	6.2	47	3
El Al	6.1	31	1
CPAL	4.7	50	1
Iberia	2.2	29	1
Irish International	0.3	9	—[3]

[1] To nearest 100,000 tonne-kilometres
[2] To nearest 1,000,000 tonne-kilometres
[3] 210,000 tonne-kilometres

Source : IATA World Air Transport Statistics, Number 4 of 1960.



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Increasing flying speeds and traffic density are imposing steadily increasing demands on air traffic control. Our communications equipment for control center, approach and tower combine decades of experience with current and future requirements.

Our line of air traffic control equipment includes special facilities for

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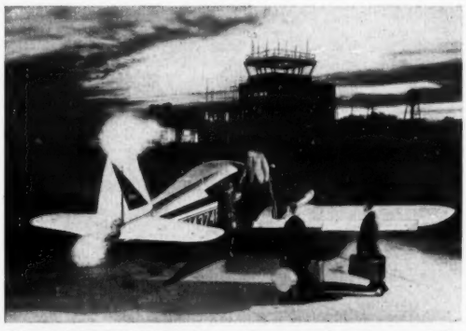
PIPER AZTEC, newest, largest, fastest of the Piper twins, cruises over 200 miles-per-hour. With a one ton useful load it can carry five passengers, complete radio and instrumentation, and full 144 gallons of fuel. It is powered by two 250 hp Lycoming engines, has very high single-engine ceiling: 10,500 feet at 4,400 pounds; 8,800 feet at 4,800 pounds gross weight. The *Aztec*'s cabin is quiet, roomy, luxuriously appointed.

PIPER APACHE G, newest version of the world's most popular twin-engine executive aircraft, cruises over 170 mph, with range up to 1,260 miles. Carries four or five passengers. Powered by two 160 hp Lycoming engines, it is among the most economical twin-engine aircraft to own, operate, and maintain.

IN MILITARY USE Piper Aztec is in use with the United States Navy for general utility purposes.

Whether you choose the Piper *Aztec* or the Piper *Apache G*, your new Piper twin will bring you these world-famous features: Safe, easy flying characteristics; outstanding short field ability; rugged construction; big, husky landing gear with large-size nose wheel for safer operations in soft, rough fields; reliability, and minimum maintenance.



IN CIVILIAN USE Piper Apache G is the world's most widely used executive twin-engine airplane; selected by the College of Air Training, Hamble, England, for all twin-engine training of pilots destined for the airlines of the United Kingdom.

IN GOVERNMENT USE Piper Aztec was selected by the Canadian Department of Transport, which also operates five Piper Apaches for inspection duties, training, accident investigation, and transportation.

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FRANCE, a vital link in the European air traffic chain, is thus in the forefront of progress in the important field of air traffic control.

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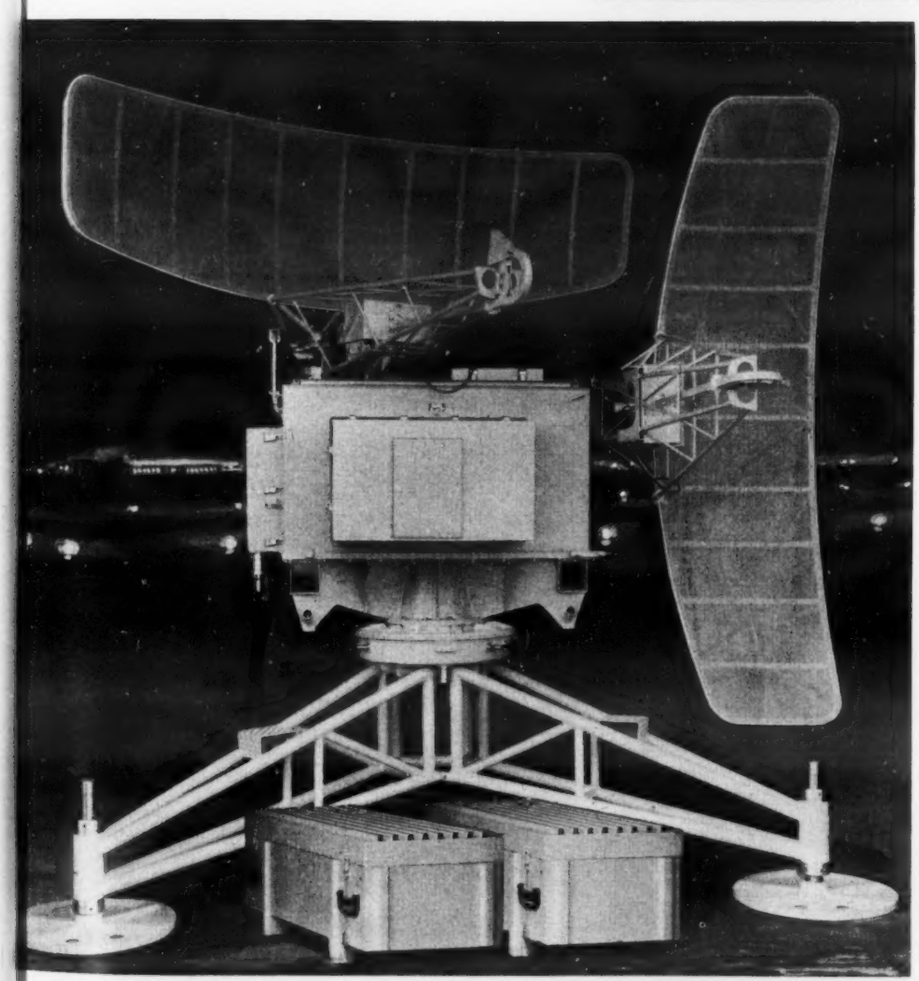

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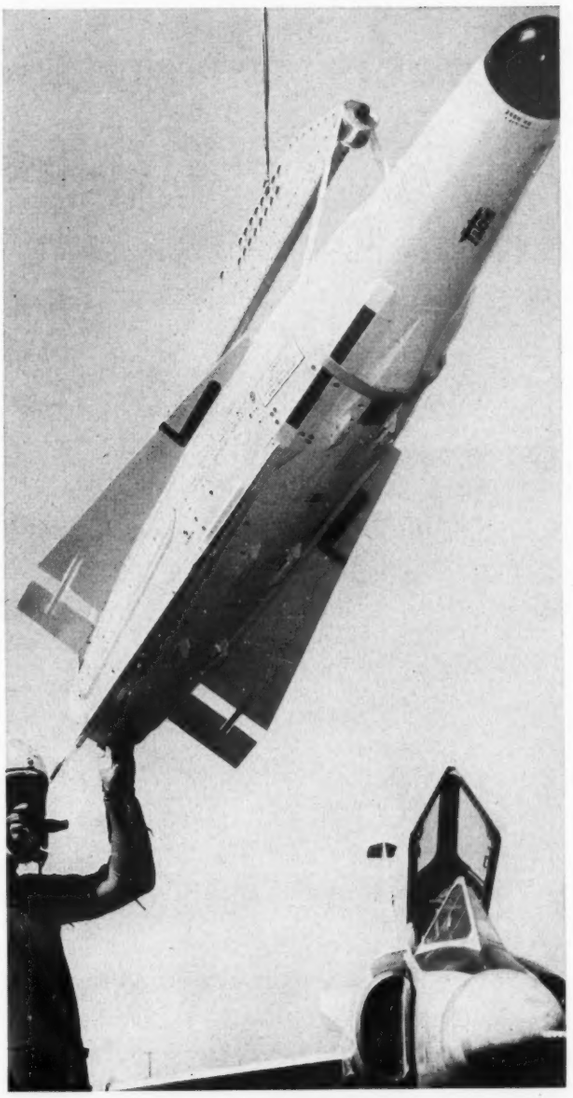
The Falcon family has proven itself in operational service — every modern U.S. all-weather interceptor carries Falcon missiles. In simulated tactical firings Falcons have achieved unexcelled records for accuracy and reliability.

Like other Hughes weapons, systems and components, the Falcon is a product of Hughes' unique capabilities in virtually every area of advanced electronics. These include projects in space systems, airborne control systems, microwave communications, data processing and display systems, ASW systems, radar and IR detection systems — and many others.

These advancements in the state of the electronic art are based on foresight, imagination, and proven management capability. Their reliability and operational capabilities have earned them the confidence of users throughout the free world.



Larger than earlier Falcons, yet small considering its extended capability, the new Falcon is 7 feet long, 11 inches in diameter and weighs slightly more than 200 pounds.

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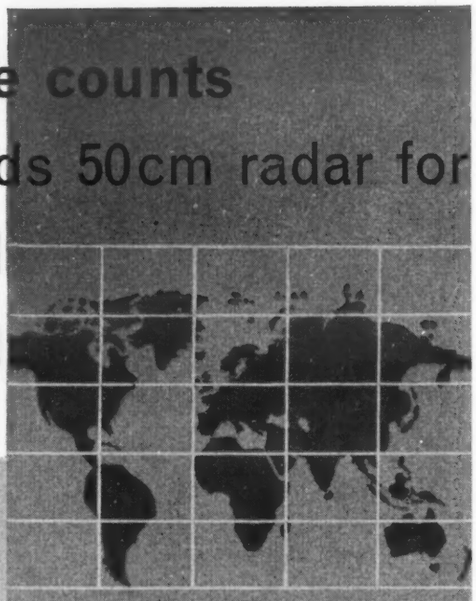

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Brussels
Warton
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Hatfield
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Birmingham
Rome
Jersey
Bretigny
Wellington (N.Z.)
Ostend
Copenhagen
Ohakea (N.Z.)
and the Royal research establishments at:—
Farnborough
Bedford and
Pershore

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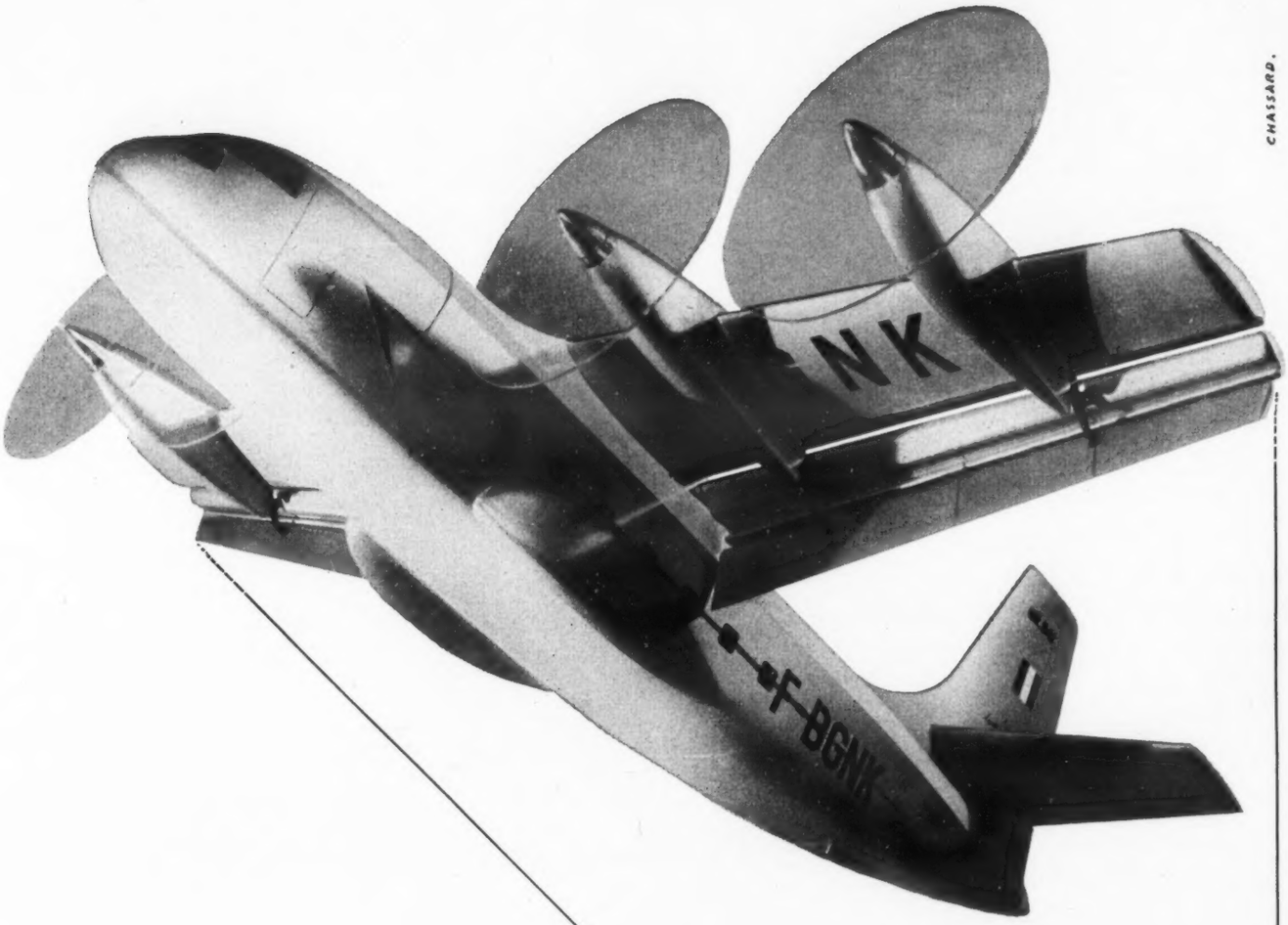

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Outside the existing network of major air routes with the long runways required by conventional airliners, the BREGUET 941 is in its element ; designed to operate from small, unprepared landing grounds, it can carry, at a speed of 250 m.p.h., not only 40 comfortably seated passengers but also an impressive volume of freight (as much as 5 tons on 1,000-mile stage lengths). The BREGUET 941 will bring air transport to areas hitherto inaccessible owing to the absence or inadequacy of landing grounds, thus giving airlines almost unlimited scope for their activities.

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The Northrop T-38 supersonic jet trainer is now

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The *Armstrong-Whitworth Argosy C Mk. 1 for the Royal Air Force Transport Command will be fitted with Marconi AD2300B Doppler Navigator and Track Guide Computer.

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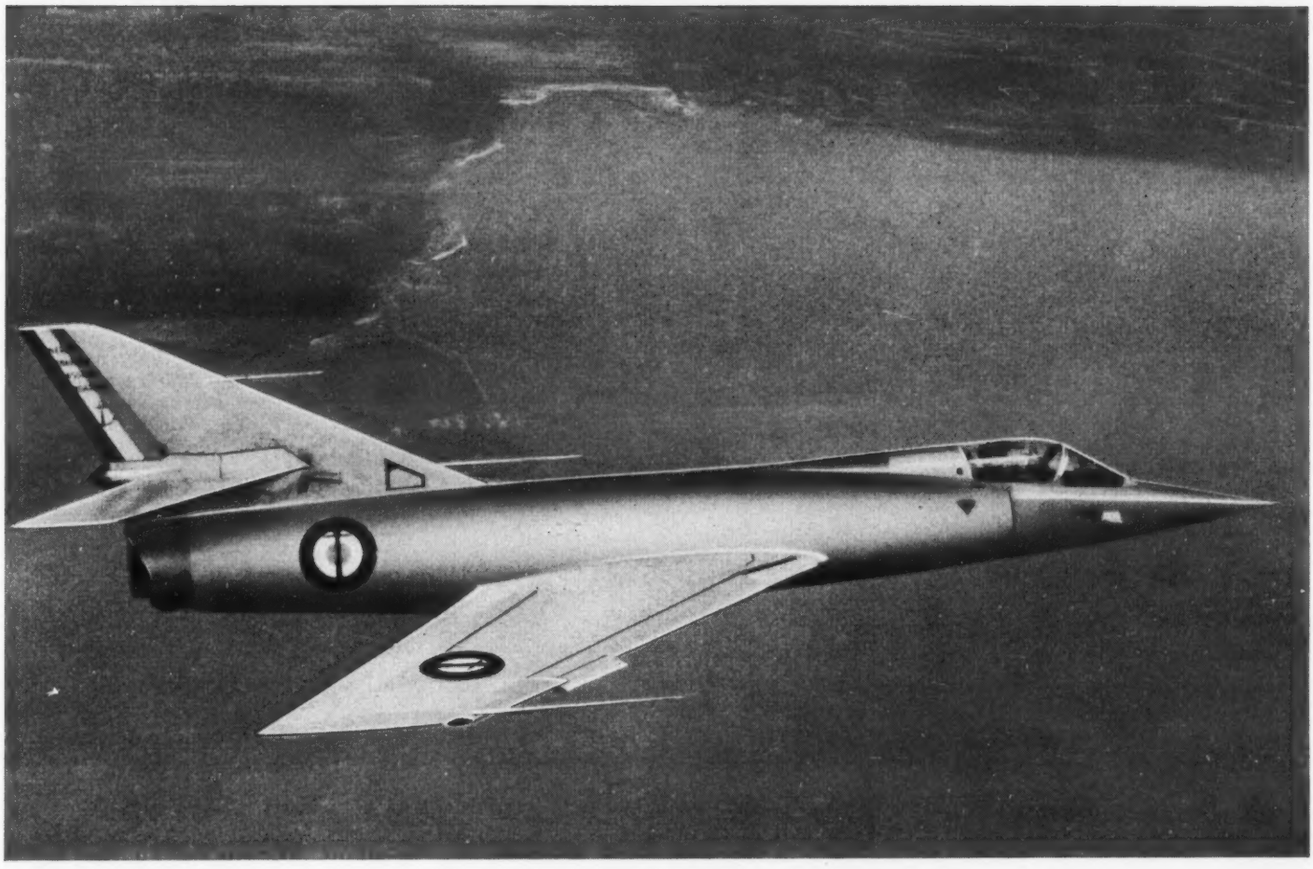

FRANCE CHOSES SAAB BT 9 TOSS BOMB COMPUTER

IN SERVICE WITH

THE ROYAL SWEDISH AIR FORCE

AND
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NOW IN PRODUCTION FOR AERONAVALE FRANÇAISE

SAAB – A PIONEER IN PRECISION TOSS BOMBING

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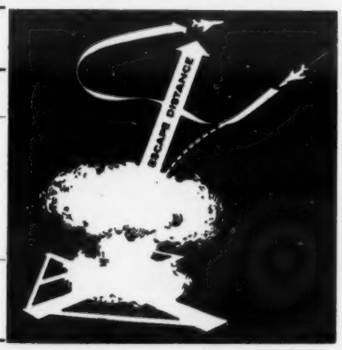
Saab BT9 Toss Bomb Computer Range of applications	
Altitude	0—6,000 m (0—20,000 ft)
Speed	M=0.5—1.0
Dive angle	10°—50°
Acceleration in pull-out	3—7 g
Maximum slope distance	1,000—15,000m.(3,300—50,000ft.) (depending on speed, dive angle and bomb characteristics)



After thorough testing in France and in competition with other equipment, Aeronavale Française has ordered the SAAB BT9F Toss Bomb Computer for its carrier-based Marcel Dassault Etendard IV fighter-bombers.

The BT9 functions in principle as an analog computer. In a dive,it automatically registers altitude, dive angle, and other variables, from which it derives the correct release point. The pilot only has to direct his plane towards the target and press a pickle switch. Bomb release is automatic. With an auxiliary device, the BT9 is also suitable for firing air-to-ground rockets.

The BT9 which is the latest in a long line of SAAB toss bomb computers is produced by the Company's Jönköping Division.

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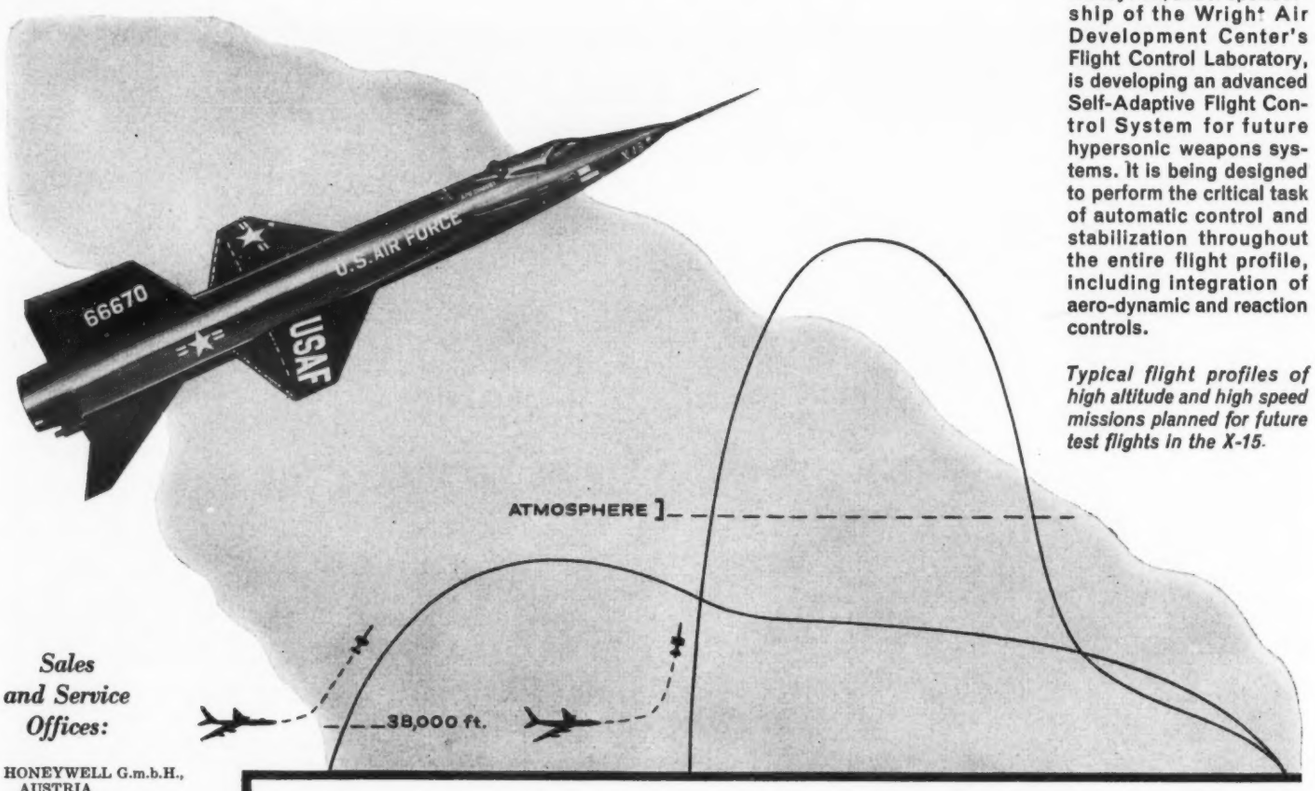

Honeywell, under sponsorship of the Wright Air Development Center's Flight Control Laboratory, is developing an advanced Self-Adaptive Flight Control System for future hypersonic weapons systems. It is being designed to perform the critical task of automatic control and stabilization throughout the entire flight profile, including integration of aero-dynamic and reaction controls.

Typical flight profiles of high altitude and high speed missions planned for future test flights in the X-15.

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The Honeywell Self-Adaptive Autopilot is designed to deliver optimum performance for every type of flight vehicle

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Simplicity—Needs no air data information for gain scheduling—is not significantly affected by design modifications in aircraft, asymmetric loading or center of gravity changes—is easily mechanized and needs little tailoring to specific vehicles—is 45% smaller and lighter—requires 50% less power.

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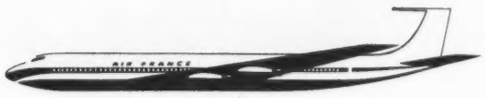

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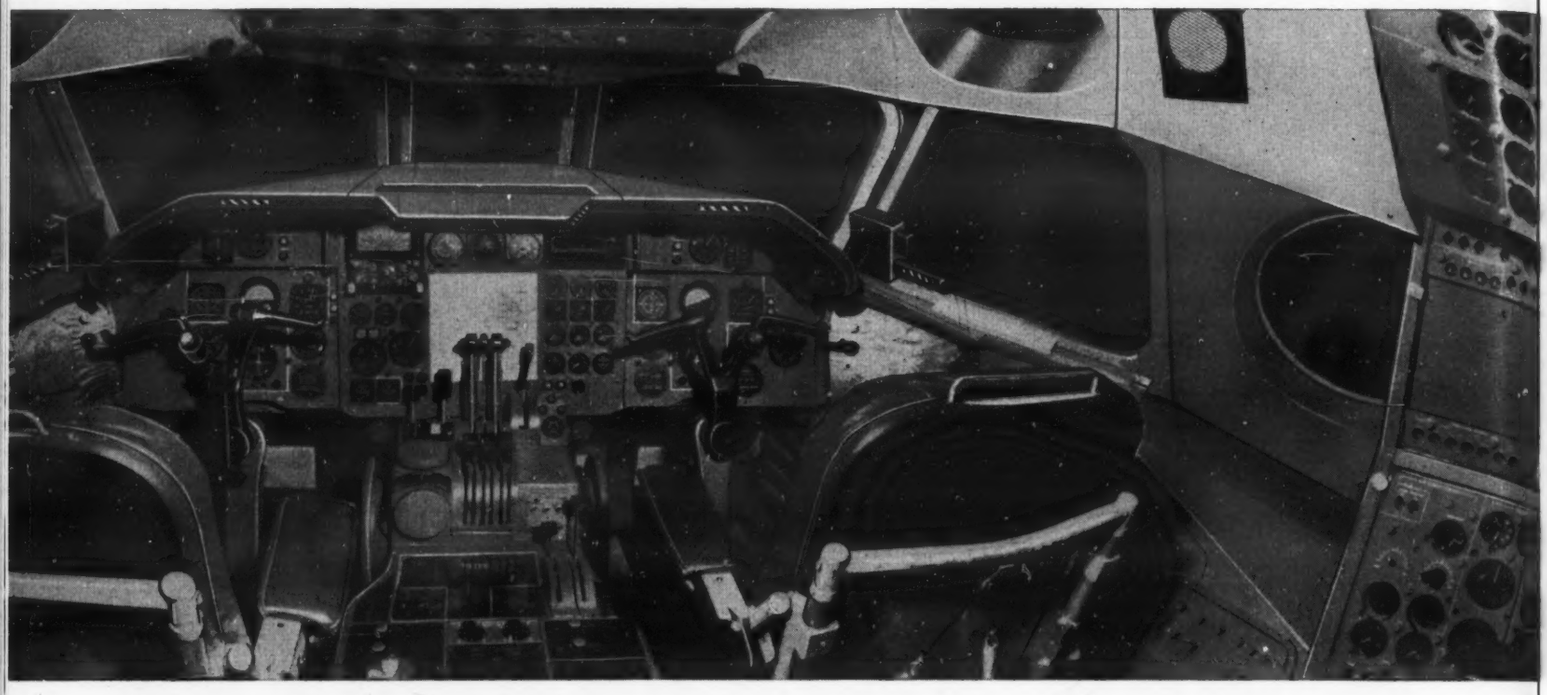
Smiths are in the picture



This is a mock-up of the BEA de Havilland Trident cockpit. Smiths equipment has been specified to provide automatic flare control when the aircraft enters service. Smiths S.E.P. 5 automatic pilot (the pilot's controller is in the bottom centre of the picture) operates on the Multiplex principle and will, ultimately, provide full automatic landing facilities to civil safety standards. Smiths Para Visual Director (P.V.D.), a revolutionary flight director display, can be seen around the panel coamings. In the Trident Smiths P.V.D. will operate in conjunction with the new Smiths integrated Flight System, specifically designed in conjunction with BEA to fit the Trident's operational role.

Over 40 Smiths instruments are in the Trident cockpit and Smiths supply, in all, no fewer than 215 individual items of equipment including the Fuel Contents System.

To both aircraft constructors and operators Smiths —a name with a world of meaning—means an organisation with first class research, design and engineering facilities. One name to solve all your instrument problems; navigation, engine, fuel measurement and flight control . . . when it comes to instrumentation, let Smiths put you in the picture.

The Smiths Para Visual Director (P.V.D.) Display Unit—an entirely new concept in flight director display. In the BEA Trident, three units are sited about each pilot. The centre unit indicates bank demands while the side units provide pitch director information. The P.V.D. may be used as a conventional flight director instrument, coupled to localiser and glide path for use in low minima weather conditions and as an effective visual monitor of the autopilot.

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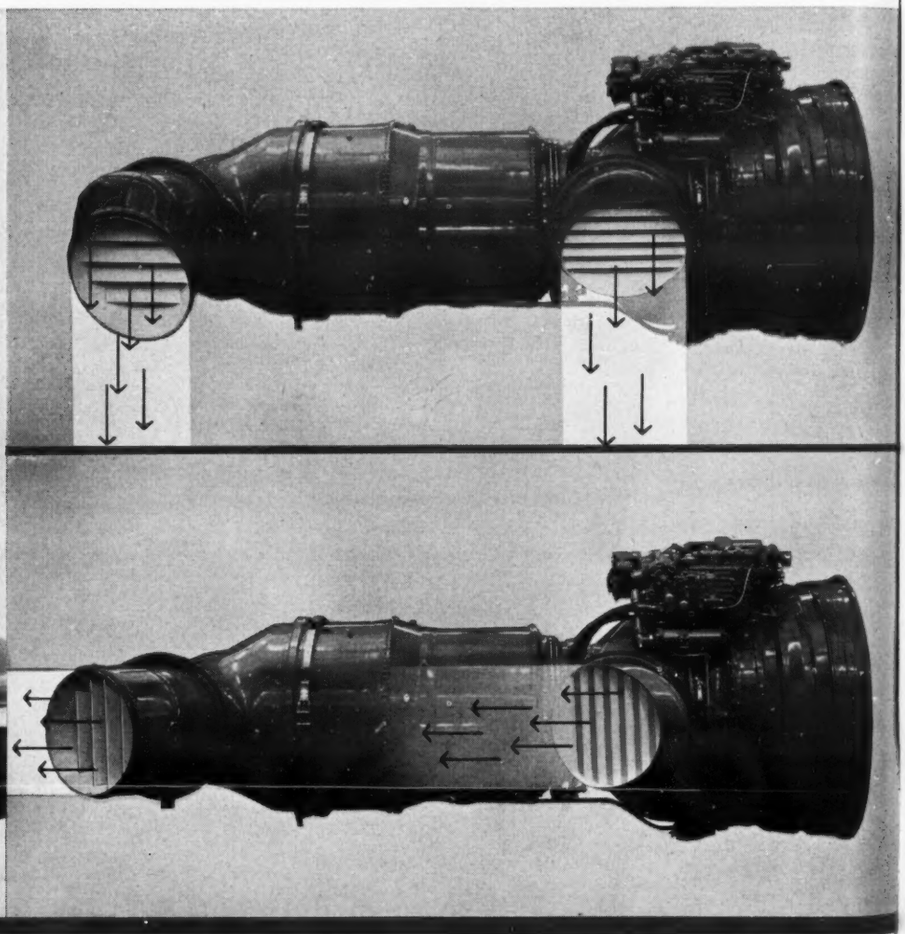

The new Bristol Siddeley BS 53 high-ratio turbofan represents a major engineering breakthrough in the field of aircraft propulsion.

Because the BS 53 can be fitted with movable nozzles evenly disposed around the centre of gravity which give directional control to its total thrust, this remarkably versatile engine provides the airframe designer with *a single power source for all conditions of flight.*

VTOL, STOL and normal take-off capability in the same aircraft. Suitable for subsonic or supersonic applications.

High cold-flow ratio gives high thrust for low weight, low fuel consumption and low noise level.

Conventional installation. Operational simplicity. Independent of all fixed ground installations.

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The Bristol Siddeley BS 53 has already been selected for, and is now undergoing trials in the Hawker P 1127 VTOL light strike fighter and is supported by the Mutual Weapons Development Programme for NATO.

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Of Land and Water...

When the first VTOL prototypes appeared, when the *Atar Volant* spewed fire, smoke and dust over the runway at Le Bourget and the *Flying Bedstead* aroused excited comment in England, VTOL enthusiasts direfully predicted the imminent end of airports. That these prophecies have proved completely false has been shown by the long list of airports and terminal buildings which have recently been placed in service. Nor have things yet reached the stage where still more noise will be inflicted on the already long-suffering city-dwellers and VTOL landing platforms will be set up on roofs. Extension programmes for airports with miles of runways far from city centres are proceeding with unabated vigour. If the Americans are spending millions of dollars on their ground installations—the new buildings at New York International Airport cost some $300 million—the Europeans are scarcely lagging behind. According to an official document published by the Paris Airport Authority, no less than NF 480 million ($96 million) had been spent on Orly by the end of 1960.

The theme of airports is therefore not obsolete, but on the contrary highly topical. If the April issue of *Interavia* has selected Orly Airport, Paris, as an example, this is because its planning, design and operations incorporate a number of noteworthy ideas which can in many respects be considered as pace-setters for the future. Not for nothing has the clearance method known as the "Orly system" been recommended by ICAO as standard practice for the EU-MED (European-Mediterranean) region.

In the articles which follow, members of the Paris Airport Authority report on the salient features of the installations which they have developed. Although the new Orly Airport is ready to receive traffic, building is going on, as in all the other airports of the world.

*

A further section of this issue is devoted to the hydrofoil boat, in which the aircraft industry, not for the first time in the course of its history, has "gone to sea." Flying boats, carrier-borne aircraft, and guided missiles for surface vessels and submarines are now being joined by hydrofoils. With the hydrofoil boat the aircraft industry is again on the way to revolutionizing transport, as it has done time and time again since the beginning of the century. If today the leading firms in the West's aircraft industries have suddenly returned to the decades-old principle of the submerged hydrofoil, this is a sign that the market promises to be rewarding. An important potential customer has already appeared on the scene: navies are looking for rapid anti-submarine and coastal patrol vessels. With the technology already at its disposal, the aircraft industry has a solid foundation for the development and production of "speedboats on wings." ←→

Reflections on an Air Terminal

By Pierre D. Cot, General Manager of the Paris Airport authority

Pierre Donatien Cot was born in 1911 and studied at the Ecole Polytechnique and the Ecole Nationale des Ponts et Chaussées. He first worked as a civil engineer in the ports of Boulogne and Le Havre, and after the war was in charge of reconstruction work at the latter port. In 1951, Pierre Cot was appointed Director of Projects and Works at Paris Airport, of which he became General Manager in 1955. In this capacity he played a decisive part in the construction of the new airport at Orly, in the modernization of Le Bourget and the installation of the Paris-Issy heliport. Pierre Cot, who is a member of the Airport Operators Council and of the Western European Airport Operators Conference, has often been consulted by various European, Middle Eastern and Far Eastern Governments on problems in both air and maritime fields.

"Are we not all familiar, moreover, with the layout of an international airport? As we emerge from the aircraft, we see (over to our right or left) a lofty structure wrapped in scaffolding. Then the air hostess leads us into a hut with an asbestos roof. Nor do we suppose for a moment that it will ever be otherwise. By the time the building is complete, the airfield will have been moved to another site."

"PARKINSON'S LAW," Chap. VI, by C. NORTHCOTE PARKINSON

After London, Nice, Algiers, New York, Brussels, Bordeaux, Copenhagen, Marseilles, Montreal and Rome—to mention only the most recent inaugurations—now Paris—Orly, where the airport authority is putting a new air terminal into service. This is of course a moment of satisfaction but it is also the moment of truth, when the results of ten years of study, thought, and comparison will be put to the test. How will they stand up to the realities of everyday operation?

Architecturally, we have the reassuring opinions expressed by visitors who saw the terminal installations shortly before completion. We were told that this central zone of the airport was a success and that the purity of style in its buildings and the harmony in its *décor* did full justice to the meticulous care taken by our talented architects and engineers, who left nothing to chance. I can speak in this matter without false modesty: the original arrangement of the central zone at Orly was conceived by my predecessor, Louis Lesieux, and its realization is due to the skill of my colleagues. In this connection, I would like to mention in first place Henri Vicariot, both civil engineer and architect, who is well known as one of the rare international specialists on airport questions and needs no introduction from me.

However, granted that a fine façade implies a satisfactory plan, and a good plan careful organization, the organization has still to prove its worth.

For some years now, the inauguration of an air terminal has become the great moment in an airport's life. Is it the rarity of the event, in Mr. Parkinson's sense, which arouses the public's interest? Or is it perhaps more the attraction of any important technical achievement for the public, provided it stimulates the imagination? Doubtless most visitors to airports are inspired by deeper things: the charm of a continuous procession of arrivals and departures which have an attractive air of mystery; the curiosity to rub shoulders with passengers, in all their wide variety, who have come or are going so far and so quickly; the satisfaction of feeling on easy terms with the powerful and fast machines and the men to whom they are entrusted.

This close connection between air terminals and crowds—the travelling public as well as the other public—points to the necessity of adapting the terminal and the airport, of which it is the principal organ, to local conditions. Whereas air navigation techniques have to be strictly standardized—witness the close resemblance between two control towers—airport techniques lend themselves to many different interpretations, as is shown by the variety of airport terminals which exist even for handling similar traffic.

This variety also proves the difficulty of deciding initially on the design. If there was one design really superior to all others, would it not be the one applied in all cases? And if, despite the efforts of so many engineers and architects, this master design has not yet been found, this is surely because it does not and cannot exist, since the basic elements of the problem differ from one airport to another. It is illusory to strive for uniformity in organizations which are in close contact with big cities, with their very different elements and wide variety of social groups. As only one example, consider how different is the problem of visitors and persons seeing off passengers in, say, the USA as compared with the Mediterranean coast.

Having said all this, our ideas must be explained. Shall I surprise you by saying that the organization of air transport owes a great deal to the railways, especially to those on the other side of the Atlantic? Nothing resembles an American railway ticket as much as an IATA air ticket. And if, when I was very young, a railway journey invariably included spending a while in waiting rooms, where the passengers were carefully segregated by class, it is well known that this is a thing of the past. Why then is air transport still in the "waiting room" age? And why, on the surface at least, are matters so complicated that one feels compelled to put the passenger in the care of a nurse, called a hostess?

I well understand that there are advantages in this system, above all for airlines, who are always afraid of losing a passenger, and even for some passengers, who are afraid of missing the plane. If some progress is to be made, however, the airport must be arranged in such a way that passengers can proceed alone, without any possibility of making a mistake, and at the right moment reach the gate in front of which stands their aircraft or

This aerial photograph gives an idea of the size of the new building, whose east wing (in background) is formed by the old Aérogare Sud. Most of the roof is taken up by a visitors' terrace. The long anti-blast barriers on the apron enable even the heaviest jet aircraft to manœuvre under their own power without endangering the building or operations at neighbouring aircraft stands. In the background are the two shorter north-south runways.

General de Gaulle, President of the Republic, inaugurating the new terminal building on February 24th, 1961. Operations began of the night of March 7th to 8th.

the bus that will take them to it. We have tried to ensure this, firstly by studying the route which the passenger must follow, and then organizing the terminal complex along this route, whereas all too often air terminals have been designed to facilitate the work of the airlines, or of the customs, or maybe of immigration control.

What our English friends refer to as our "Orly System" is of course the underlying idea of our original plan: as soon as the international passenger, duly registered at the airline desk, is freed of all worry about his non-hand luggage, which is inspected by customs at the same time as it is weighed in, his movement through the terminal is very nearly as quick and simple as if he was taking a domestic flight, as the remaining controls which he has to undergo before he can board the aircraft, namely immigration and customs, can be kept very short.

Some of the men whose tireless efforts have made Paris Airport what it is today. Left to right: Louis Couhé, founder of the independent Paris Airport Authority, Chairman of the Board from 1948 until his retirement in June, 1960, and today Managing Director of Air France; Pierre Boursicot, Chairman of the Board since July, 1960; Louis Lesieux, General Manager of Paris Airport from 1948 to 1955.

At the only two points where he might hesitate which way to go, he is guided by effective light indicators. Immediately before the gate leading to the plane, there is a room for assembling the passengers very shortly before embarkation. In the interest of passengers, we want the airlines to make reasonable use of these assembly rooms, particularly by allowing passengers to board the aircraft as far as possible in advance. Here again, one should draw on the example of the railways, where continuous boarding, spread over a certain period, has solved the problem of crowding in stations, at the same time satisfying those travellers who wish to arrive well ahead of time, unlike the "regulars" who turn up at the last moment.

As far as arrival is concerned, the problem is simple, as there is only one direction to go—towards the exit. Here again the "Orly System" combined with a self-claim baggage service—a system tried out and perfected at the Orly-Nord and Le Bourget terminals—considerably simplifies and speeds up the exit procedure.

We believe that in this way we have eliminated one of the causes of time-wasting and some of the sources of annoyance. This of course assumes that the airlines in particular will adapt their methods as necessary in order to use the tools we have put at their disposal.

For this reason, we invited the airlines and various services, such as air traffic control, customs, police, oil companies etc., to send their own staff for instruction to our training school, side by side with the staff of the airport authority, who maintain the port services for numerous companies. We have for some months been carefully training the staff of the air terminal and auxiliary installations by means of special courses, in some cases involving the simulation of real conditions.

I do not propose to dwell on the other aspects of Orly air terminal, except to mention that we have made determined efforts to develop the income we receive from the commercial activities at the terminal. These include the establishment of a shopping centre comprising everyday shops, intended more for the airport staff than for the travelling public (to avoid obstruction, this is in the basement); numerous concessions in the "shopping gallery," where passengers and their friends can, if they wish, wait together and not take leave of each other until the last moment; duty-free shops in the transit lounge; restaurants of various categories; a hotel in the terminal itself; and huge terraces for visitors.

Last but not least, an excellent motorway, which is being extended every year both into the city and into the suburbs, as well as numerous and practical means of transport, have, so to speak, brought Paris nearer and made it possible to cut out all passenger and baggage registration operations at the town terminal, which only increased the loss of time on the ground. Henceforward the passenger knows that his journey begins or ends at Orly, just as in any railway station. In fact, it hardly takes longer to reach Orly than to reach a Paris railway terminus. Whatever some people may think, this represents appreciable progress. ←

Paris-Orly

Building Design at Orly

By Henri Vicariot, Chief Architect, Paris Airport authority

Born in 1910, Henri Vicariot is both a civil engineer and a distinguished architect. He joined the Paris Airport authority in 1947, where he now is in charge of the General Design and Architectural Department. Henri Vicariot is well known as a specialist in air terminals and airport construction in general. His activities have extended to various foreign airports for which the Paris Airport authority has done planning work, and he has been called in as adviser at Rom, Athens and São Paulo.

The public zone of Orly Airport, otherwise the terminal zone, includes all the installations in direct contact with commercial traffic (passengers and freight) and the public at the airport, namely:

a) the air terminal proper, the technical and administrative services, and the auxiliary services (hotel rooms, medical service), all of which are concentrated in one main building;

b) the freight building;

c) car parks, service stations and car repair shop at the disposal of passengers and public;

d) technical and administrative buildings of the French national flag carrier Air France;

e) other possible amenities not yet built, such as a hotel, an enclosure with attractions for visitors etc.

For the purposes of this article we shall confine ourselves to the general design and points of architectural interest in the main building which, for the public at large, is now the new Orly air terminal.

General design and system

The new Orly air terminal is of the "concentrated" type, comprising two fingers parallel to the façade. On the "city" side there is one level and on the "runway" side two levels. The terminal works entirely on the "Orly system" for both departures and arrivals.

Passengers move on two levels—the lower floor on the "city" side, where they register their luggage on departure or take delivery of it on arrival, and the first floor with a single immigration channel for departures and arrivals. The fingers are on two levels, the first floor containing two parallel galleries (one under customs control and the other public) and the ground floor comprising waiting rooms and premises for the runway service.

Luggage moves on the lower floor only. As regards the luggage of departing passengers, customs checks are made at time of registration. For incoming luggage, a self-claim baggage service has been adopted, and passengers pass through a customs channel at the exit to the baggage delivery hall.

Having described in outline the system underlying the new air terminal, we can now go into more detail.

Passenger traffic at Orly is estimated at a maximum of six or eight million per year. The air terminal which has just opened was designed to handle four million passengers in its first phase and six million in its second phase. In the overall plan of the terminal zone, provision has been made for the possible construction of a terminal for domestic airlines.

The concentrated two-finger terminal is a traditional method for providing terminal facilities for 22 aircraft stands, and was deemed suitable in this case. The maximum distance which has to be covered on foot at peak hours between the centre of the terminal and the end of the fingers does not exceed 400 yd, or the length of a railway station platform. After studying the question, it was decided to build the fingers parallel to the façade on the "runway" side rather than at right angles; by avoiding a "courtyard" shut-in on three sides, this arrangement simplifies aircraft manoeuvres and reduces the undesirable noise and smell from jet aircraft.

Not only the services directly concerned with traffic but also the technical, administrative and auxiliary services have been assembled under one roof in the main building; in accordance with user demand, the principle of concentration has been applied to the maximum possible extent.

To the north, on the "city" side, is a four-story administrative block 660 ft long, built over the registration and baggage delivery halls. To the south, on the "runway" side, are the restaurants, situated above the large shopping gallery and above the huge 500 ft long waiting room on the first floor. In this waiting room passengers and public find the usual facilities and shops of a large air terminal. In short, the only original feature of the working of Orly air terminal is simplicity.

To the north, the terminal is on one level on the "city" side, and here there is a long pavement where cars can draw up. In the central part, four covered parks are reserved for buses.

On the "runway" side, the terminal is on two levels, with the immigration channel for international passengers on the first floor. It is here that hand luggage is checked by customs and passports by immigration officials, and it is at this point that international passengers take leave of their families (or are met by them). Domestic airline passengers do not pass through this channel, but proceed through a public gallery direct to the gate corresponding to their flight.

The procedure for passengers subject to customs and immigration control, which has been outlined, follows from the application of the "Orly system," as recommended by the European-Mediterranean Region of ICAO and used in practice in most recent terminals.

This is the way the terminal building looks to the passenger arriving from Paris. In the centre is Route Nationale No. 7, which runs under the building, the apron and the main runway; the access lanes from the motor roads are to right and left.

Paris-Orly

For transit passengers, a very large waiting room has been provided on the second floor, including duty free shops and all necessary facilities, such as toilets, showers, hairdresser, nursery, bar and restaurant. A small chapel will also be open to them. Eighteen hotel rooms and two VIP lounges have been installed. The first floor has a press room, specially equiped for televised interviews and including nine telephone booths as well as the equipment necessary for small press conferences. It is intended to have a 270 seat cinema on the fourth floor. On the third floor, "runway" side, there are, running from east to west, a first class restaurant (capacity 250 persons and facilities for dividing off into a number of small rooms for private parties), a bar-tearoom, and a tourist class restaurant for 250 persons. A brasserie is installed on the fourth floor, where there are possibilities of large scale extension on to the outside terrace. A restaurant (with own kitchen) for the airport staff has been provided on the second floor.

All the terraces in the building are accessible to the public by spacious interior and exterior staircases, and there are three controlled entry points—one inside and two outside—in different parts of the central building.

To prevent the entry of exhaust odours from jets, the scale of ventilation has been doubled and the air inlets include active carbon filters. In the façades facing south on the "runway side" 18 mm glass has been used for the shopping gallery; elsewhere the glass is 10 mm. All the interior ceilings are soundproofed. The whole terminal is equipped for broadcasting on the whispering system by the installation of a very large number of low-powered loudspeakers (2,900) in the ceilings.

All in all, the new building may well be compared with a large ocean-going liner.

Architecture

From the early planning stage, the building was designed so as to permit its exact dimensions to be calculated without waiting for the working plans to be completed. An exact standard dimension was adopted which furthermore made it simple to establish the layout of all parts of the building. The whole terminal is constructed to a system of squares 8.28 m × 8.28 m and, 828 being divisible by 2, 3, 6 and 9, all dimensions can be given in an integral number of centimetres. The importance of this seemingly minor detail was apparent throughout the design and construction stages. The choice of 8.28 as the basic dimension was also influenced by surveys of the known elements of the air terminal, namely the luggage registration counters with conveyor belt, the offices of various sizes and the galleries for passengers and public.

Originally, before details of the networks of pipes and cables of all kinds were known, space was reserved for them in the plans as follows:— horizontally, in all parts of the building between the floor and ceiling, otherwise occupied only by the mainly lattice type girders; vertically, numerous large trunks (there is one 690 ft in section) wherever vertical shafts, such as staircases and lifts, occur. Despite the fact that provision for trunks and conduits was made on a generous scale and these were designed large, they proved in practice inadequate at certain points and had to be made bigger than foreseen.

Play of light and shade on concrete and glass. The staircase runs to the visitors' terraces on the roof of the terminal building.

The architecture of the air terminal is expressed in the large horizontal lines of the balconies, from which passengers and visitors can observe the aerial scene. There are glass screens, which stop at the first floor and start again at the third, to protect them from the blast of jets and to some extent from the noise too. These balconies also have the advantage of shielding the glass of the façade from the sun, and are thus a simple answer to the problem of protecting the building against external heat.

Architecturally, the administrative block is designed in such a way that it is possible to install a portable screen on each mullion, i.e. every 1.38 m (this being one sixth of the standard measurement of 8.28 m).

It will accordingly be clear that the air terminal has two very different faces, the north being the simple and severe one of the large administrative buildings, whilst the south presents the more varied face of an air terminal designed for the comfort and pleasure of the public and the passengers.

These two "faces" have been brought out by the material used in construction of the façades. The administrative block is in deep sea green enamelled glass, with slender ribbing in glazed stainless steel, which constitutes the framework of this façade; the south side and the fingers are,

Generously designed and equipped... The shopping gallery on the upper floor. In addition to the traditional tobacco and newspaper kiosks, there are a florist's, parfumery, cake-shop, fashion boutique, jeweller's, shops selling leather goods, china, pottery, wines and spirits, a bar and a post office.

Glass, white stone, dark green serpentine and "Orly-blond" anodized aluminium are the dominating features of the entrance hall.

on the other hand, in aluminium which shines in the sun and stands out in contrast to the coloured mass of the administrative block.

The spaciousness of the halls on the ground and first floors have allowed the use of modern monumental architecture, which has, however, never abandoned the simplicity appropriate to an air terminal; examples are floors flagged in white Comblanchien stone, aluminium-covered pillars, marble or serpentine slabs, treated aluminium or painted steel ceilings.

The colours were deliberately chosen to achieve contrast between the ground floor hall, which faces the "city," and the sales gallery, which looks towards the aircraft. On the ground floor there is sound harmony between the deep green of the serpentine, the gilt of the aluminium and the red of an immense decoration in relief. On the first floor, there is the light and delicate atmosphere of the white marble, sky-blue ceiling and light gold of the aluminium. Special mention must be made of the latter material, anodized in a special shade, now known as "Orly-blond," midway between gold and natural aluminium colour.

Traffic Development at Paris

During the first year of operation of Paris Airport, the total traffic at Orly and Le Bourget Airports amounted to 720,000 passengers and 23,000 tonnes of freight and mail. By 1960, the former figure had increased more than fivefold to a total of over 3,600,000 passengers, and the latter nearly fourfold, with 82,000 tonnes of freight and mail.

There are few enterprises which can boast of such increases during the brief period of eleven years. On the French Railways, for instance, the tonnage of goods transported rose by a mere 40%, and the number of passengers has shown a slight decrease. The passenger traffic of French maritime ports has increased by only 50%, and freight by 65%. Likewise, although the output of electricity in France has risen sharply since the end of the war, it increased by only 140% between 1949 and 1960. The growth of traffic volume at Orly and Le Bourget, which reflects in its turn the growth of air transport in France as a whole, is therefore particularly remarkable.

A year-by-year analysis of traffic is given in the accompanying table.

Whereas only 30 airlines served Orly and Le Bourget in 1949, by 1960 the number had risen to 80, from 31 different countries. Forty-four of these companies are scheduled operators; seven are French.

Today, Paris is linked by air to 137 cities of the world: nine in France, 44 in Europe, 39 in Africa and 23 in America.

In 1960, Paris Airport recorded the following peak traffic figures:

monthly peak (September): 400,000 passengers;
weekly peak (September 2nd to 8th): 98,000 passengers;
daily peak (July 31st); 15,500 passengers.

A systematic study of these peak traffic figures has enabled planners to outline the equipment required for the two airports of Orly and Le Bourget, whose new installations must be adequate to ensure the uninterrupted flow of traffic during the next ten years. At Orly in particular, the new terminal installations must be capable of handling an annual volume of six million passengers, representing 2,000 passengers transported in 20 long-range aircraft at certain peak periods.

Between 1949 and 1960, and particularly during the last two years, the average number of passengers transported per aircraft showed a distinct increase: from 19 in 1950, it rose to 30 in 1955 and 36 in 1960, and in the latter year was 53 for the *Caravelle* and 54 for the Boeing 707 and Douglas DC-8.

Paris Airport's traffic volume makes it the second in Europe (after London) and the eighth in the world.

Year	Aircraft Movements	Passenger Movements	Freight (tonnes)	Mail (tonnes)
1949	55,700	720,000	17,600	5,000
1950	63,500	929,500	22,000	5,600
1951	74,600	1,169,200	26,000	6,400
1952	80,200	1,269,300	28,000	6,400
1953	81,000	1,463,700	26,000	7,500
1954	86,900	1,664,200	28,900	8,800
1955	84,100	1,847,600	30,700	9,100
1956	103,900	2,307,400	42,200	12,700
1957	111,600	2,573,400	42,500	13,600
1958	116,900	2,679,300	44,500	15,900
1959	117,800	2,973,700	52,100	17,800
1960	126,300	3,637,600	60,600	22,500
Percentage growth 1949-1960	+ 127%	+ 405%	+ 244%	+ 350%

Three examples of the interiors of public facilities. Above: the transit lounge with bronze-green carpet, white marble columns and walls panelled in rosewood. Right: the snack bar with blue plastic floor, wooden ceiling and Formica bar top. Below: the "Three Suns" first class restaurant, which takes its name from the Lurçat tapestry in the background. There are tables to seat 200 and a small dance floor. Different coloured lights of variable intensity illuminate the plastic ceiling and change the atmosphere of the restaurant to suit the mood of the moment.

Each of the restaurants has its own special characteristics. Luxurious for the first class restaurant, elegant for the bar-tearoom, unpretentious for the second class restaurant and the snack bar, more rustic for the grill and, finally, homely for the 4th floor brasserie.

The indicators are generally speaking luminous. The panels are of thick plexiglas and enclose a lighting unit. Systematic colours have been selected: deep blue letters on a light blue background for directing passengers to departures, red on yellow for arrivals, and white on blue for locality markers.

*

Not counting the preliminary planning and surveys, the whole project (survey, design, and construction) took a little over four years, and in this period an extremely complex building of nearly 1,400,000 sq. ft. was completed at a cost of over 120 million new francs. At the same time, work was started and completed on the section of Route Nationale No. 7 to Fontainebleau, which passes under the terminal zone.

The result, already familiar to the public and passengers using Orly, is that the new air terminal is taking the countenance first glimpsed more than ten years ago by the engineers and architects of Paris Airport authority. ←→

Layout of the Central Zone

By Jacques Vasseur, Equipment and Installations Manager, Paris Airport authority

Born in 1916, Jacques Vasseur entered the Ecole Polytechnique in 1934 and graduated from the Ecole Nationale des Ponts et Chaussées in 1939. He has since held appointments with the Service Maritime du Nord et du Pas de Calais, the Le Havre Port Authority and the Service des Ponts et Chaussées at Rabat; since 1955 he has been Equipment and Installations Manager at Paris Airport, and led the team which designed the new terminal complex.

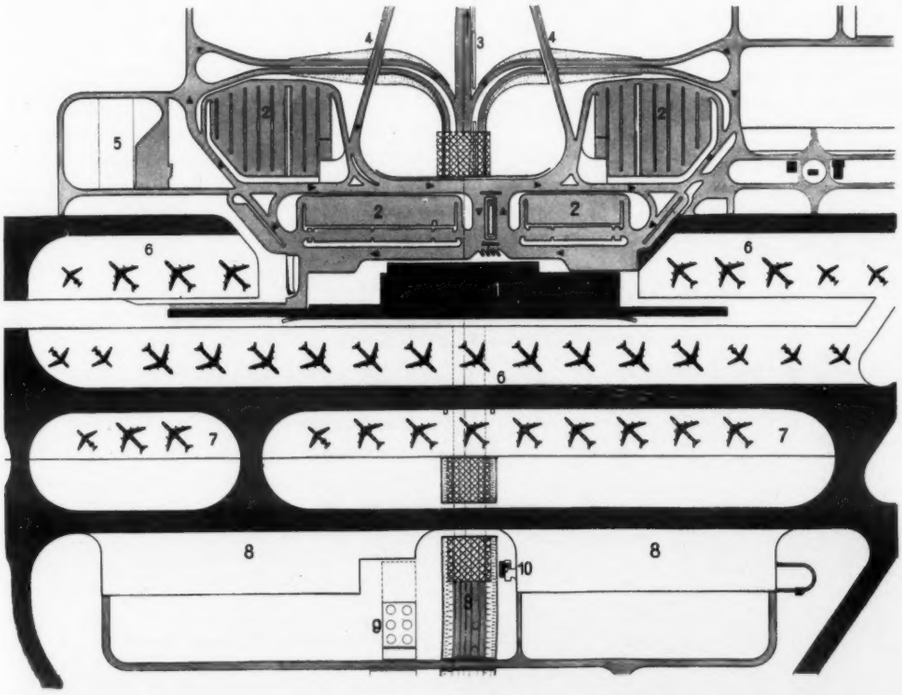
The air terminal — city side

The Orly air terminal is on a single level on the city side. Without discussing in detail the reasons which have led planners to prefer this layout to the so-called "split level" arrangement, it is clear that its adoption requires the meticulous organization of surface traffic if congestion in front of the terminal building is to be avoided.

In the case of Orly Airport, the problem is complicated by the fact that the terminal is served simultaneously by the southern motor road, from which two one-way lanes branch off to arrive at each end of the building, and by the Paris—Fontainebleau highway (Route Nationale 7) which, crossing the airport from north to south, passes under the terminal and the aircraft stands.

In working out the traffic arrangements (see below), planners were faced with two problems:

– the inevitable junction between the lanes from the motor road and the road linking the terminal building with the Paris—Fontainebleau highway (in the direction of the southern suburbs of Paris and Fontainebleau and between the terminal building and the service roads parallel to Route Nationale 7). As studies had revealed the importance of traffic on these roads and the impracticability of level crossings, it was necessary to provide two fly-over crossings near the terminal apron;



Traffic facilities in the terminal area, as they will be when the final phase of construction is complete. Buildings are shown in black, aircraft taxiways in dark grey, roads and parking areas in light grey. 1 – terminal building; 2 – car parks; 3 – Route Nationale No. 7 from Paris to Fontainebleau; 4 – access lanes from motor road; 5 – fuel reservoirs; 6 – aircraft stands (stands with the silhouettes of four-jet aircraft have a diameter of 220 ft, the others have a diameter of 190 ft); 7 – stands which are normally used only for parking aircraft, but which can also be used for loading, when passengers will be transported to the aircraft by bus; 8 – apron for aircraft making intermediate stops; 9 – underground fuel reservoirs, each with a capacity of 35,300 cu.ft.; 10 – 79 ft control tower from which apron movements can be supervised and lighting controlled.

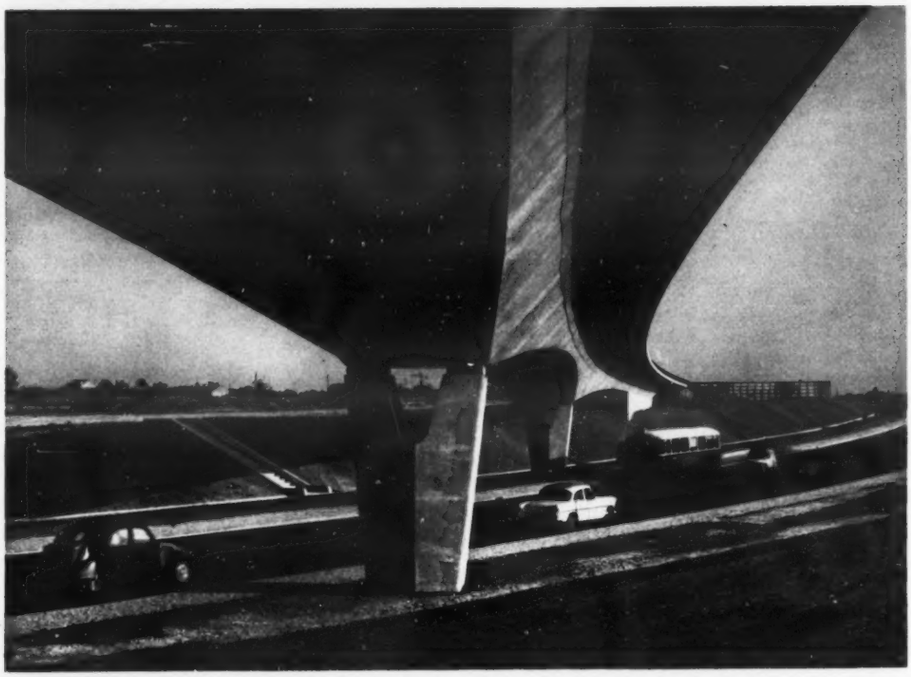
– the second problem arose on the north side of the terminal building, where the road was to be reserved for vehicles which had to stop beside the building. This was solved by directing fast traffic to a road about a hundred yards north of the terminal façade, over a bridge crossing Route Nationale 7, and by making a clockwise direction obligatory for all vehicles using the airport so that they pass by the side of the terminal building when travelling from east to west. In this way the space in front of the building is cleared of all fast traffic, so that vehicles and pedestrians can move freely and safely between the car parks and the terminal building.

Between Paris and the terminal building, the road network is exceptionally good; a direct link with the southern motor road enables the seven miles between the terminal and the outer roads to be covered rapidly and without level crossings. Airport bus services will, of course, use this road, which could also be used by a line of the Régie Autonome des Transports Parisiens, whose terminus, situated at the Denfert-Rochereau underground station (Orly is about 20 minutes from Denfert by bus), would offer convenient connections with the Paris underground railway network.

For private cars, parks have been provided which will be progressively enlarged to correspond with the expansion of private motoring. The first phase of car park construction provides for a capacity of 1,850 vehicles; in addition, a so-called "long-period" garage for 300 cars will be available for passengers, who can leave their cars at the airport during the period of their absence in the knowledge that they will be adequately sheltered and serviced.

The terminal — airport side (aircraft apron area)

The terminal is laid out so that aircraft in front of its façade and the length of its fingers can be loaded and unloaded directly. The latter each serve two sets of aircraft stands, one along their north face, one along their south face. The aircraft stands are in fixed positions marked on the ground, spaced so as to make allowance for the



The lane crossing over Route Nationale No. 7 leading to the southern motor road. The terminal building, visible in background, was still under construction at the time this photograph was taken.

dimensions of the largest aircraft which are likely to use them.

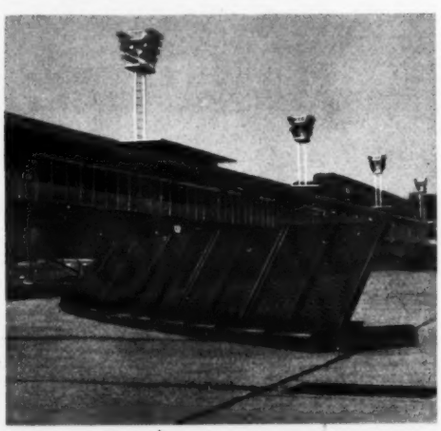
There will thus be sixteen stands along the southern façade of the terminal building and its fingers, and nine stands on the northern façade of the fingers, making a total of 25. It is difficult to imagine the outer stands being used without mechanized transport, as this would involve a walk of 100 to 150 yards in the open from the ends of the fingers; the number of stands which can be reached on foot is thus 22. These should suffice to meet the requirements of normal daily peak traffic (hourly peak traffic has been estimated at 1,500 passengers during the first phase and 2,100 passengers during the second phase). To cope with exceptional peaks, however, twelve additional stands will be provided, running from east to west to the south of the terminal, on the other side of the taxiway running parallel to its façade. During normal traffic periods, these will be used for parking aircraft.

These latter stands will be served by buses arriving at the central terminal gates, which can thus be used both for aircraft waiting directly in front of the terminal building and for those farther away. An underground gallery has been built from the basement under the passenger halls in the terminal building to a point south of the stands; this will enable a third finger to be built parallel to the terminal building at a later stage, for direct access to the stands to the south of the terminal apron.

All stands will be provided with highly efficient anti-blast barriers to protect the façades of the terminal building and the fingers, and also aircraft manœuvring on arrival and departure. The stands can, of course, accommodate aircraft parked "nose inwards" perpendicularly to the façade. Aircraft in this position cannot leave the stands under their own power, but will have to be towed by a high-performance vehicle to the taxiway parallel to the terminal building. This is the only drawback to this mode of parking, which has undoubted advantages and which would later enable covered gangways to be built from the galleries on the first floor of the fingers.

The 2.6 million sq.ft. apron in front of the terminal is built entirely of concrete on a bed of rubble; the concrete layer, 16 inches thick, can support aircraft weighing over 200 tons.

After two years of tests on wooden anti-blast barriers at Le Bourget Airport, the design shown in the picture has been adopted at Orly. The metal grids are inclined at an angle of 60° to the jet exhaust, but only partially obscure visibility, although they are 5.6 ft high.



All the aircraft stands bordering the terminal and its fingers will be equipped with fixed installations for refuelling aircraft and supplying them with electrical power. Connections have been provided for portable telephones on the aircraft gangways; later, channels will be installed for the supply of units of heat or cold for the ground air conditioning of aircraft.

Refuelling

The petrol companies operating at Orly Airport have formed a group, known as "Société de Manutention de Carburéacteurs Aéroport d'Orly" (SMCAO), which will operate a system of underground jet fuel supply lines and run other services.

The use of the fixed installations for the distribution of two different qualities of fuel will remain optional, and petrol, which is now being consumed to a lesser extent, will be distributed, as before, by refuelling trucks.

The liveries of both personnel and equipment will be in the colours of the company which employs them.

The maximum delivery rate of the jet fuel supply valves has been fixed at 550 Imp.gal./min, i.e., 275 gal./min per fuel intake of a four-engine aircraft, and 1,100 gal./min for the whole aircraft.

Electrical power supply, telephone connection and related equipment

The aircraft stands will be equipped with underground chambers closed by swing hatches, each containing an electrical connection, a telephone connection, an earth connection and, if required, a cutoff switch for the fuel supply installations.

Electric current is three-phase, 380V, 50c/s, and the power available at each connection is approximately 200 kVA. As the characteristics of electrical equipment vary from one aircraft to another, current can be supplied only via a converter, which is far more practical and economical than a mobile generator unit.

The telephone connection is linked with the airport network by an armoured cable with three pairs of cores, and may also be linked with the postal and telecommunications network.

An earth connection is accessible directly from the aircraft stand without the necessity to open the hatch. This is used during refuelling operations.

A switch enables the aircraft fuel supply pumps to be stopped by remote control.

Operation of airport apron

The airport apron is controlled both by the airport operating authority and the national authorities responsible for air traffic. Both keep watch on the movements of aircraft and other vehicles on the apron and the airport as a whole from a 79 ft control tower with a clear view on all sides. ←→

Electrical and Thermal Power Supply

By Jacques Block, Paris Airport authority

Jacques Block, who is a graduate of the Ecole Nationale des Ponts et Chaussées, is Chief Engineer of the Electrical and Industrial Installations Department of the Paris Airport authority.

Among the many problems posed by a large modern airport is that of satisfying its power requirements, the most common of which are electricity and heat. These are of considerable magnitude, the total electrical power requirement for all users of Orly Airport being of the order of 14,000 kVA, with an annual consumption of 30 million kWh, and the power capacity of the airport's heating installations over 300 million B.T.U./h, with an annual output of over 600,000 million B.T.U. These requirements are comparable to those of a town of 30 to 40,000 inhabitants and are continually on the increase as Orly develops.

An airport has, however, certain problems and possibilities which distinguish it from a town. If the safety of air traffic is to be ensured, electric power must be supplied without interruption to certain installations, such as runway lighting, radio navigation aids and transmission systems, and this requires emergency generators and a special network to supply so-called "priority" installations. On the other hand, it is easier to find a rational solution to the heating problem on an airport—a relatively recent institution—than in a town, as calories can be produced in large and economical power stations and distributed by a network of channels to all buildings in the same way as kilowatt-hours or cubic feet of water.

1 – Electrical power supplies

The power necessary for approach and threshold lighting and the lighting for a 10,000 ft runway may be as much as 300 kW. If the runway is equipped for landing in poor visibility in both directions, this figure must be doubled. Orly has at present three landing directions equipped with very high intensity lighting, and the construction of two new runways, which is envisaged at a later date, means that up to four runway lighting systems will be in operation simultaneously, representing a power of over 1,000 kW. To this must be added the taxiway and apron lighting, whose future requirements can be estimated at 150 kW, and the power supply for radio aids, telecommunications, the control tower and its annexes, which may require up to 250 kW. Priority requirements will thus total up to about 1,400 kW.

There are other installations, which, although emergency power does not have to be supplied in a fraction of a second as in the case of the foregoing equipment, nevertheless require permanent electrical power. These are as follows: safety lighting, lifts, fire-fighting pumps, automatic doors, baggage conveyor belts, pneumatic tubes etc. At present, the power requirement for all these systems is 1,000 kW, but the emergency power supply which is immediately available is limited to 500 kW. In future, however, it will doubtless be possible to double this figure.

Orly Airport has thus had to equip itself to produce emergency power of the order of 2,400 kW. Since the classical solution of instantaneous, automatically starting diesel generator units is impracticable for such a high power, it was decided to have normal power requirements supplied by an independent electrical power station at the airport, drawing on the external network only in the event of an emergency. The airport power station, which went into service in 1960, is at present equipped with two 1,500 kVA steam turbo-alternator units, with a third to be installed at a later date.

The entire network is monitored from the power station control room (see picture), where an illuminated circuit on the wall shows cables and generators in red or yellow. In the event of a current failure, the light turns green, and if a cable is damaged the line which represents it begins to flash. The official on duty can thus immediately localize a fault and isolate the faulty section by remote control. If a current failure occurs, an automatic switch will immediately connect the priority installations to the external network.

Among the non-priority systems are the power and lighting circuits of the airport buildings, such as the terminal, hangars, workshops, shops, offices, and the lighting for roads and car parks.

There are also the extensive power requirements for electromechanical equipment. In the terminal building, for instance, there are no less than 18 passenger and goods lifts, 21 escalators, 16 baggage conveyor belts and 52 automatic doors, not to mention the air-conditioning fans, which change the 14 million cubic feet of air in the building three times an hour, or the electrical equipment of the kitchens, which can serve up to 2,000 meals simultaneously.

2 – Heating power

The thermal requirements are mainly for heating the buildings. In the new terminal building the installed power reaches 90 million B.T.U./h, i.e., approximately 78 B.T.U./h per square foot of floor space. The figure is approximately the same for the most recently built hangar and its annexes. In addition, hot water requirements are considerable in all seasons.

Two power stations are at present equipped. Each generates a power of 136 million B.T.U./h, and the capacity of the more recent one can be doubled. Both produce hot water under pressure at a temperature of 16°C. In the buildings, this "primary" hot water is piped either directly to radiators in the ceilings, which are an excellent solution to the problem of heating large buildings such as hangars and workshops, or to exchangers where it heats secondary hot air networks for ventilation heating, and provides hot water at temperatures varying between 40 and 90°C for sanitary installations and classical radiator and convector heating. In summer, it can be used for absorption coolers in certain parts of the buildings.

The more recent of the two power stations is better described as a thermo-electric than a heating plant, for it contains the turbo-alternator units and the control room for the priority electric power supply previously mentioned. High-pressure boilers operating on heavy oil produce steam at a pressure of 711 lb/sq.in., which drives expansion turbines. Part of its energy is used to produce priority kilowatt hours, and the remainder is converted to primary hot water in a condenser. From this principle, it follows that the production of heat from the boilers is dependent on the amount of electricity generated. As heat and electricity requirements vary according to season and hour of day, a number of devices enable the correct balance to be maintained at all times.

In order to reduce initial and operating costs, the Paris Airport authority has sought to concentrate its heat and power generators and distribution network. Although the authority has achieved its aim, this concentration and the need to ensure extreme reliability of operation have naturally involved an increase in technical complexity, accompanied by a rise in maintenance costs and the requirement for more qualified personnel.

It has therefore been considered advisable to ensure that production units, while large, are independent and standardized, capable of coming to each other's aid and permitting a reduction in the number of spare parts and simplified personnel training. The possibility of using natural gases to drive the power turbines and boilers hence appears one of the most promising solutions for the future, as it will enable the desired economy, independence and simplicity of operation to be achieved, while contributing to the solution of certain secondary problems such as that of atmospheric pollution from smoke. ⟷

The entire power network can be monitored and controlled from an illuminated plan on the wall of the control room (left), where cables and transformers appear in red or yellow. If the current fails at any point, the corresponding symbol turns green ; if a fault occurs, the symbol representing the faulty cable or transformer begins to flash. The controller can thus localize the fault at once and isolate the faulty component by remote control. In the event of a failure in the power station itself, the main airport installations are automatically supplied with current from the public mains. The airport lighting systems appear on the second plan (right). Space for the projected extension of the airport has already been reserved on the illuminated plans and control console.

The New Terminal Installations at Work

By François Didier, Paris Airport authority

Born in 1930, François Didier is a graduate of the Ecole Polytechnique and the Ecole Nationale des Ponts et Chaussées. From 1953 to 1957, he took part in the reconstruction of facilities destroyed during the war. Responsible since November, 1957 for the general operation of the terminal installations at Orly and Le Bourget, François Didier is also technical adviser on ground organization to the Minister of Public Works and Transport, a post which he has held since February, 1959.

The placing in service of a complex of installations as vast as the new Orly terminal and its traffic arteries on the city and airport sides requires years of preparation. Most of the work of designing and developing new equipment would be wasted if it were not accompanied by progress in organization and personnel training.

In 1955, Paris Airport established a Terminal Service with an engineer, Roger Maurel, as Manager. This service is responsible for the general operation and management of the installations, and provided the basis for an organization which could work with the designers right from the start. In 1958, a planning section was set up to supply the architects with detailed information on the necessary equipment and facilities and suggestions as to the layout of premises. The fact that the Chief Architect, Henri Vicariot, is also Chief Engineer of one of the departments of the Terminal Service, did much to facilitate cooperation.

The requirements dictated by general policy, the choice of equipment and the size of the facilities gradually crystallized. Early in 1960, the Service, now known as the "Orly Terminal Installation Service," received reinforcements of personnel, and Pierre Jarniou, the Chief Engineer of the airport Organization and Methods Service, was seconded to aid in the installation of facilities and the engagement of personnel.

The installations cover a floor area of 1,356,000 sq.ft., comprise some 1,400 different facilities and will ultimately employ 1,500 persons. In 1960, the daily traffic average was 7,500 passengers and 170 aircraft movements, with peaks of 10,000 passengers and 200 aircraft movements. If visitors and those accompanying passengers are added to these figures, over 30,000 persons a day will at times be passing through the new terminal, which at any given moment will accommodate 5,000.

Operation

From every point of view—quality of service, economy of administration, public safety—the size of the installation requires a highly efficient organization. Careful examination of the problem resulted in the following plan which, as Henri Vicariot remarks, bears a marked similarity to the layout of a passenger steamer. Each of the two technical services responsible for airport maintenance and operations is represented at the terminal by a qualified official, who has the entire responsibility for the activities of his service. Under his orders is a small team of skilled workmen and technicians, who systematically check and maintain equipment which is not covered by maintenance contract with suppliers. A Central Technical Office on the lower ground floor, equipped with control consoles and monitoring units, looks after the actual operation of the equipment and running repairs. This facility is supervised by a single official, permanently assisted by two repair specialists who make spot checks on installations such as pumps, compressors, exchangers and filters, and who can be called to any part of the terminal complex for urgent repair work. The installations are equipped to permit the use of portable radio sets; this facility benefits not only the airport services, but also airlines, public services and licensees. The Central Technical Office represents, as it were, the "engine" of a steamer.

It was also necessary to provide the equivalent of the "bridge." The size of the public facilities and their distribution throughout the building made it advisable to concentrate the control and monitoring equipment at a single location; this was particularly necessary in the case of the lighting system, in view of the substantial power requirements. Although the Central Technical Office on the lower ground floor can issue orders and check the functioning of the installations, it cannot adapt their operation to meet the ever-changing traffic requirements. Another permanent office, the Central Control Office, located on the ground floor on the town side of the terminal building and entirely enclosed by glass, has therefore been provided. This is operated by an official of the Terminal Installation Service, who monitors and supervises the public facilities, the operation of escalators, lifts, and the heating and ventilation plants. He is kept informed of all technical hitches in public or private premises and takes emergency measures, if need be with the aid of the Central Technical Office. Two further officials make the rounds of the building and transmit their reports to the Central Control Office by service telephones installed in the corridors. Their duties in no way concern traffic operations, but play a vital role in ensuring reliable operation of the installations.

Television cameras for the remote supervision of the main halls will be installed at a later date, if it is found that these would be of assistance in achieving economy.

Traffic

The organization described above is designed to keep the installations permanently operative, and the fact that its existence is unnoticed will be the best proof that it is working satifactorily. But its aims do not, of course, constitute an end in themselves, for the terminal has been provided to handle airline departures, arrivals or transit movements. An adequate traffic organization has therefore been sought after, and in this connection reference has often been made to the organization of a large railway terminus without, however, losing sight of the fact that a number of companies serve an air terminal (25 in the case of Orly) against a single operator at a railway station.

Until the present time, the problem has not been acute, as traffic has been served by two terminal buildings, both of which were small, and there have been no fingers leading to aprons. There has therefore been no systematic coordination of the passenger circuits inside the building with the aircraft positions on the aircraft stands. The situation is very different now, as all compa-

The main power circuits and heating and ventilation distribution lines are monitored and remotely controlled from the technical control room in the basement of the main building, in accordance with instructions received from the command post on the ground floor.

nies have been regrouped into a single building, designed to enable passengers to reach their departure gates independently.

The final plan takes account of the original character of Orly Airport, and integrates the airport services properly speaking with air traffic services such as approach, landing and surface movement control.

The airlines operating at Orly have been most cooperative, and have understood that it is in their own interests to let us know their projected timetables, so that we can suggest minor modifications to avoid congestion of movements. On the basis of this information, which is passed to the Terminal Installation Service some time in advance, a daily operations sheet is drawn up late on the eve of the day for which it is required. It then remains to correct this sheet in the course of the day, as and when delays are announced. For this purpose, a Central Terminal Office, located on the ground floor on the same premises as the Central Control Office, is informed by the Runway Office (a branch of the Air Traffic Control Service) of delays in expected arrival times; this is effected with the aid of a simple system enabling strips to be read off on a television screen. The airlines have also informed us of delays envisaged on departure, asking us to keep this information confidential for commercial reasons. Information received from airlines enables a table of arrivals and departures to be kept up to date for two hours in advance; this table is scanned by 7 television cameras and transmitted to all the airport services concerned. Such a system, whose price is relatively modest when recent progress in industrial television is considered, keeps each company informed of the state of flight connections; runway services, public services and concessionaires can adapt their operations to traffic peaks which are accurately forecast one hour in advance.

Yet another department, the Allocation and Coordination Office, is responsible for the allocation of aircraft stands. This office is accommodated in a 79 ft tower to the south of the main apron; from here controllers can look over the entire apron and monitor the aircraft parking areas. The Allocation and Coordination Office has a role similar to that of the "ramp coordinators" at a number of airports, though it differs in that it is jointly operated by the Terminal Installation Service and the Air Traffic Service. The permanent presence of officials from both services enables safety standards to be maintained and stands to be rapidly allocated on the basis of requests submitted by airlines to the Central Terminal Office and passed on by this department. The television network described above avoids the tiresome necessity for listening to VHF approach frequencies. Notifications are not made directly by the Allocation and Coordination Office, but pass through the control tower (ground controller), who receives them by telex.

In addition, the presence of an air traffic control official facilitates the function of the Air Traffic Control Service, as the control tower is at present sited far to the east of the airport territory, about 2,000 yards from the terminal building. The Allocation and Coordination Office will also be able to perform other tasks, such as blast and noise control on stands near the terminal, as and when the need arises. The controls for the manoeuvring areas, particularly lighting, are housed in the Allocation and Coordination Office.

Aids to the public

The organization described above coordinates traffic movements. It is of vital importance, but inadequate on its own without an organization to handle air passengers. There thus remains the problem of guidance and information.

For the indication of arrivals and departures—the present article will not deal in detail with ordinary signposting—it has not been possible to use television screens; this system, which is excellent for industrial purposes, is inadequate to guide the public in an air terminal. For this reason, a system controlled remotely from the Terminal Control Office has been adopted; perforated cards containing the necessary information are passed via flat pneumatic tubes to arrival and departure boards, where they are slipped in front of a projector. The board, located opposite the access to the shopping gallery, indicates the next 20 departures on a system of independent panels similar to those at railway stations. In the fingers, a single panel at the top of each staircase leading to the departure gates confirms the flight departing from the gate. Finally, for the guidance of passengers who must undergo police and customs clearance, a confirmation panel, listing exclusively the flights for which customs clearance is required, is placed opposite the exits of customs and passport control points at the foot of the staircase leading to the transit lounge.

In addition, the Paris Airport authority has provided three separate information desks—on the ground floor, in the shopping gallery and in the transit lounge—where airport hostesses are available to supply information.

These arrangements are completed by a network of telephones of a special colour, which give direct connection to the telephone information service behind the information desk on the ground floor. This service is also accessible by outside telephone for information on movements at Orly.

In closing, a few remarks on the placing in service of the installations are indicated. The Paris Airport authority rejected all solutions calling for the progressive transfer of operations, as periods of transit inevitably involve inconvenience to the public using the airport. A date was chosen three months in advance to fall within a slack traffic period: the night of March 7th to 8th. On the basis of a "logistic plan" prepared with the airlines one month previously, the operation, which was supervised throughout by Roger Maurel and his assistants, consisted mainly in the modification of the connections for the telecommunications systems, which had previously been duplicated. The companies were able to move into their offices at the end of January.

Finally, to avoid confusion, the switchover operation and the inauguration ceremony were kept carefully separate, the latter taking place on February 24th, ten days before. This made it possible to complete the training of operational personnel, while ensuring that the first passengers passing though the terminal found it in perfect running order. ◂▸

The Thomson-Houston Airport Television System

The television system installed by CFTH at Orly Airport is claimed by the manufacturers to be the largest of its kind in Europe. It comprises two networks: a general network for the transmission of arrival and departure times, consisting of eight television cameras and some 200 screens of different sizes, and a private network for Air France with four cameras and over two dozen screens. In addition to general information, the latter system provides detailed information for Air France.

Seven of the cameras of the general network are trained onto the central arrival and departure board in the entrance hall. A special facility houses the necessary control consoles, amplifiers, distributors and selectors. Each receiver is connected with the control room by its own coaxial cable, in some cases nearly a mile long. Remote-controlled video switches enable any of the 7 main channels to be selected without delay.

The four remote-controlled cameras of the Air France system cover the company's arrival and departure boards in its new operations building. The screens of this network are installed in a number of rooms in the operations building and in various Air France offices in the terminal building.

The command and monitoring post for the technical installations in the main building is on the ground floor, in a glass cabin in full view of the public. The plan on the wall shows the nine floors in the scale 1 : 200. The lighting installations are identified by white signals, the electromechanical installations (lifts, escalators, ventilators, etc.) by green signals. If one of the 4,000 sensors in the building records a temperature in excess of normal, a red warning lamp lights up on the plan.

Air Navigation and Traffic Control Aids

By René Aucouturier, Air Navigation Division, Paris Airport authority

René Aucouturier joined the staff of the Paris Airport authority in 1953 and has since 1955 headed the Air Navigation Division of the Direction du Trafic et de l'Exploitation Aérienne of the Aéroport de Paris.

It may be well to start with some statistics. In 1960, Orly saw 75,177 aircraft movements (landings and take-offs), compared with 48,955 movements in 1955. Five years earlier, the corresponding figure was 23,241.

These figures show, at a glance, the progressive development of traffic at Orly, but they do not tell the whole story. The increase in capacity and improvement in load factors which characterize modern aircraft mean that the increase in the number of passengers handled has far exceeded the growth in aircraft movements.

And it must not be forgotten that, like other forms of transport, air traffic has very marked peaks, both on the calendar and on the clock, which must be taken into account in planning the navigation and air traffic control systems which have to be installed.

In 1960, whereas the number of movements averaged 6,265 per month, in the month of August alone there were 7,078. Also in 1960, whilst the daily average of traffic movements was 206, 23 movements per hour were recorded on over 40 occasions during the year and, once at least, 32 landings and take-offs in the course of a single hour.

These peaks in traffic must of course be taken into account in deciding on the navigational aids to be provided and indeed on the air traffic control system as a whole. In this connection, situations occurring over forty times in the course of a year must be deemed normal. Even if commercial considerations rule out installations on a scale equivalent to the extremes of traffic seldom encountered, planners obviously cannot base themselves on figures which would lead to saturation of the airport. Today air traffic control at Orly must be able to cope with 20 aircraft movements per hour, and this may well be 30 in the near future, i.e. one take-off or landing every two minutes.

These figures are, of course, not extraordinary for a great international airport, but it should be borne in mind that they relate almost entirely to transport aircraft, as the airport is not open to light aircraft. In 1960 there was, moreover, a steep increase in the proportion of jet traffic, a development which will continue. In 1961 as many movements of jets as of propeller aircraft are to be expected.

Radio approach aids

Paris-Orly Airport is at present provided with three runways for take-off and landing, one of which (02R/20L) is, however, only used occasionally and provided weather conditions are good.

Orly's main and longest runway, 08/26, runs roughly east-west (082°/262° magnetic), and the great majority of aircraft use it, since west and south-west winds prevail at Orly. Fully loaded long-range jets in any case require the 10,892 ft of this runway, Orly's busiest. In addition, there are thickly populated areas to the north, east and south of Orly, which also favour its use. This runway therefore has the most comprehensive approach and landing aids.

For the main bad weather runway 26, a precision approach radar by Gilfillan is available as well as a most up-to-date instrument landing system developed by the Italian concern FACE-Standard. This is characterized by high stability of transmission and a symmetrical glide path, which not only ensures an extremely accurate approach path but also allows use of the autopilot during the latter phase of the approach. All important parts of the ILS are duplicated, the standby equipment being at constant readiness. As soon as the monitoring equipments detect any anomaly in transmission, the second transmitter is automatically switched on within three seconds.

Although east winds seldom prevail in Paris, and are moreover generally weak when

The central building houses the airport and approach control system and the air traffic control installations of Orly Airport. Left, the fire station; right, the former emergency power station. It is planned to build a new control tower on the terminal building; when the airport is complete, the tower will be located at its centre.

weather conditions are poor, runway 08 was also equipped with bad weather landing aids a short time ago. It would still be possible, even in easterly wind conditions, for aircraft to land on runway 26 in zero wind or with only a very slight tail wind. Accordingly it was found advantageous to use runway 08 instead, since its first section and its approach sector exhibit far better visibility conditions, especially when ground fog is present. This means that flights from the south can be reduced to a considerable extent, firstly to minimize flying over the populated areas to the south of the airport, and secondly to avoid the problems of coordinating traffic at Orly with that at Brétigny, an aircraft testing centre some 10 miles south of Orly.

For landing on runway 08 an ILS (also by FACE-Standard) has been installed. In addition, a Gilfillan "Quadradar" is in service at Orly airport, and this can be switched to cover any landing direction within a few seconds, and therefore equally well be used for landings on runway 08. At the same time it acts as reserve equipment for the precision approach radar for runway 26.

Lastly, the 7,874 ft long north/south runway 02 L/20 R (024°–204° magnetic) is available, and is equipped for bad weather landings from the south with the same type of ILS as runway 26. Moreover, the Quadradar can also be brought in for monitoring and approach control on runway 02. Landings from the north are normally not allowed, as these involve flying over the city of Paris, which is not permissible.

Independently of the bad weather landing aids, Orly is provided with a series of radio navigation aids for short and medium ranges. These include:

- A Collins VOR of low emission power, over which information concerning weather conditions, runway in use, availability of navigational aids etc. is transmitted.
- A Marconi VHF direction finding station, comprising two channels, each with five frequencies.
- a CSF surveillance radar (see overleaf).

Lighting

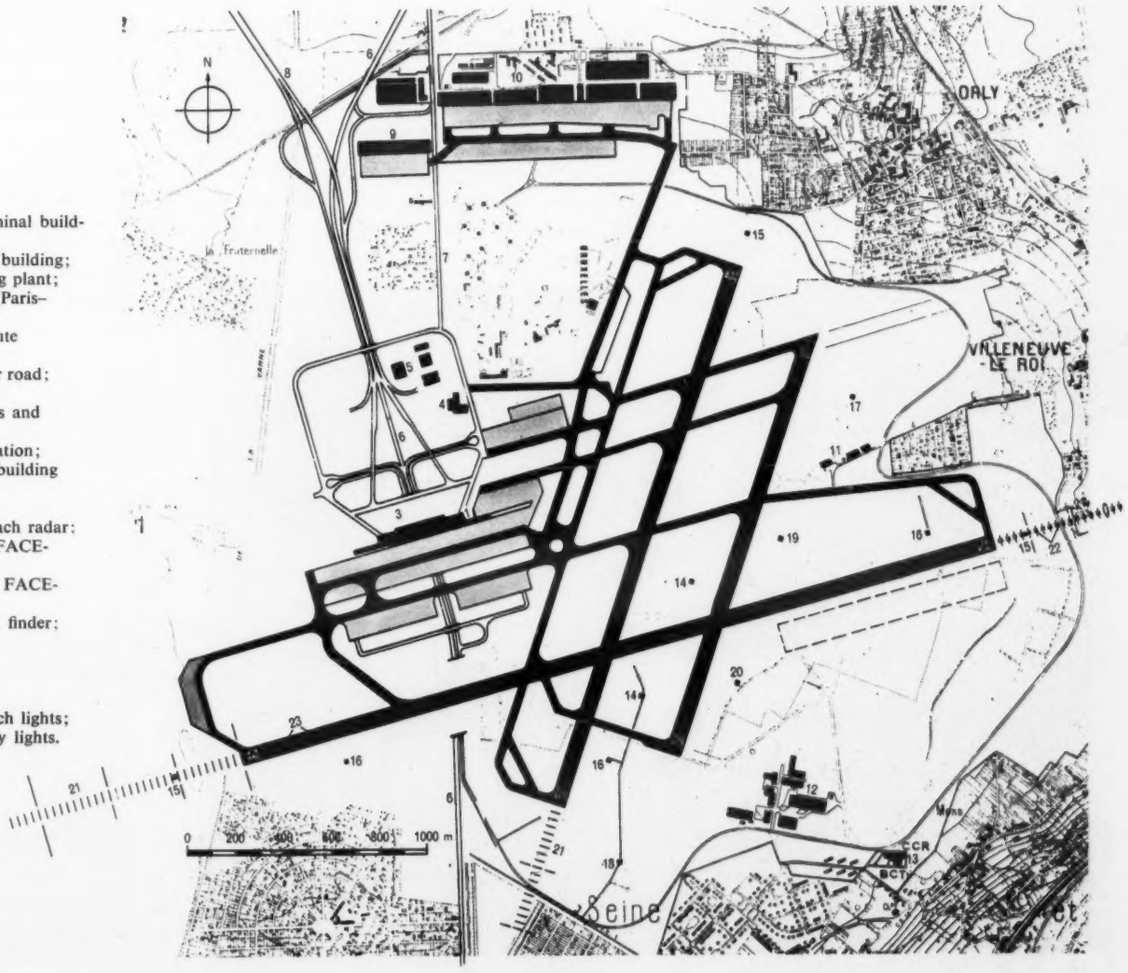
For each of the three bad weather approach sectors and runways, the high powered lighting system comprises approach lighting, green threshold lighting and touch-down lighting with separate designation of the touch-down point. The lighting has a four-stage adjustment, allowing very wide variations in intensity and thus avoiding dazzle. With the object of making the lighting system readily adjustable to prevailing weather conditions, a number of special procedures and devices are in use.

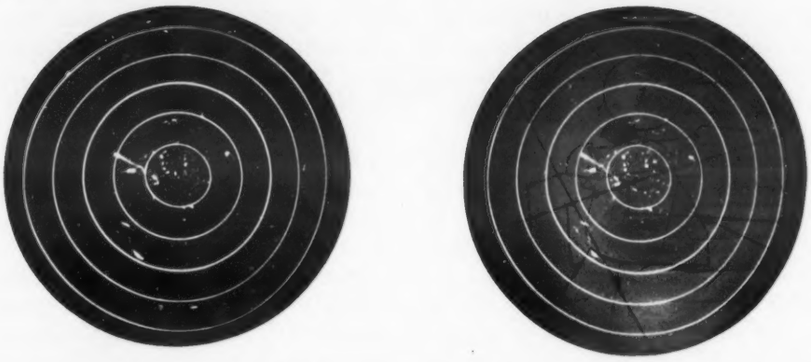
Electronic flash equipment by Sylvania is installed along the centre line of the approach lane to runway 26. This transmits successive flashes, which are very short and powerful (250 microseconds/30 million candlepower). The pilot sees a flash of light moving twice per second along the approach lane in the direction of the runway. The approach sector to runway 08 is also shortly to be equipped with similar flash equipment.

Further optical aid at the entry to runway 08 is provided in the form of a number of projectors embedded in the runway itself in groups of three, placed at intervals of 165 ft and at about 37 ft on each side of the centre line. These extend for a distance of 1,000 yards. To achieve a comparable illumination with a single projector would involve a much

Plan of Orly Airport:

1 – former southern terminal building;
2 – new terminal building;
3 – sidewalk in front of terminal building;
4 – former northern terminal building;
5 – power station and heating plant;
6 – Route Nationale No. 7 (Paris–Fontainebleau);
7 – former path taken by Route Nationale No. 7;
8 – lane from southern motor road;
9 – new hangar No. 6;
10 – older hangars, workshops and operations building;
11 – control tower and fire station;
12 – workshops, storerooms, building yard;
13 – area control building;
14 – Gilfillan precision approach radar;
15 – localizer transmitter of FACE-Standard ILS system;
16 – glide path transmitter of FACE-Standard ILS system;
17 – Marconi visual direction finder;
18 – Collins VOR;
19 – CSF surveillance radar;
20 – VHF antennas;
21 – approach lighting;
22 – Sylvania flashing approach lights;
23 – Olophane sunken runway lights.





Left, radar picture on a television screen. The CSF transmission system enables radar signals to be stored on a TMA 403 X scan conversion/storage tube which shows the tracks of the aircraft in the form of long afterglow tails. Right, the same traffic situation after a map has been superimposed on the radar picture.

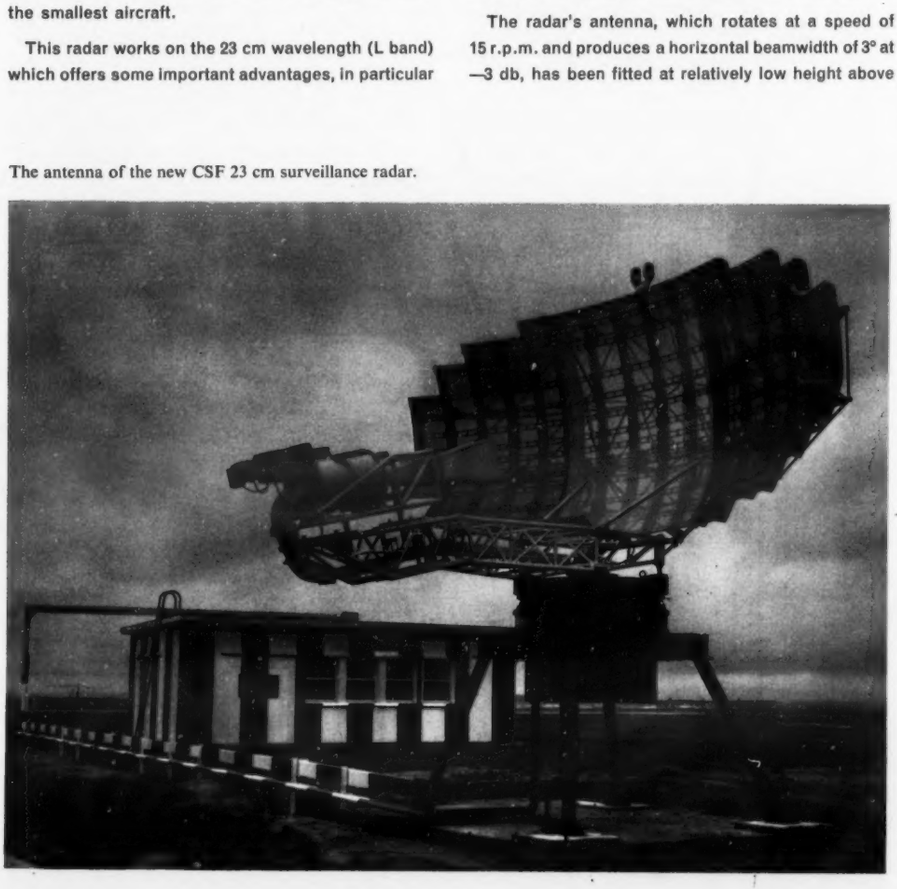
CSF Short-Range Radar

To adapt air traffic control systems to the new requirements created by the large-scale use of jets, the existing radar at Orly, whose performance had become inadequate, was recently replaced by high-power equipment with all modern refinements and a considerably wider coverage, assured by an antenna with a span of 40 ft, rotating at 6 r.p.m., which gives the radar a maximum detection range of 300 miles for large aircraft, and 125 miles for even the smallest aircraft.

This radar works on the 23 cm wavelength (L band) which offers some important advantages, in particular very appreciable attenuation of parasitic echoes due to rainfall or storm clouds; the fact that it does not eliminate them completely allows the operator to guide aircraft around zones of bad weather. If, however, he wishes to clear the screen of all rain and cloud echoes, the antenna is equipped with a servo controlled device, allowing him to switch to the circular polarization of the transmitted wave. Polarization can be set at any degree of ellipticity between linear and circular.

The radar's antenna, which rotates at a speed of 15 r.p.m. and produces a horizontal beamwidth of 3° at —3 db, has been fitted at relatively low height above ground level, so as to reduce the level of energy returned by fixed obstacles and in this way to facilitate the elimination of fixed echoes. The height has, however, been calculated in such a way that the coverage diagram is relatively free of the sidelobes which occur if the antenna is installed too close to the ground.

The antenna of the new CSF 23 cm surveillance radar.



The system works on the double diversity principle developed by CSF. Two transmitters, offset by a few microseconds with respect to each other and operating on frequencies with a difference of a few Mc/s, each transmit 700 pulses per second with a pulse length of one microsecond and a peak power of 2 MW. The pulses received on the two different frequencies are passed to two separate receivers, and the combination of the two echoes (in the form of a sum or product) ensures reliable presentation of the target on the radar screen. This allows a considerable increase, for a given range, in the probability of detection (the number of antenna rotations during which a useful echo is received as a percentage of the total number of rotations), or an increase in the radar's useful range for a given probability of detection.

The two transmitters and receivers use the same antenna; this offers the advantage that, if one of the transmitter/receiver "chains" breaks down or has to undergo maintenance, the second can continue to operate on its own, with satisfactory coverage still being achieved.

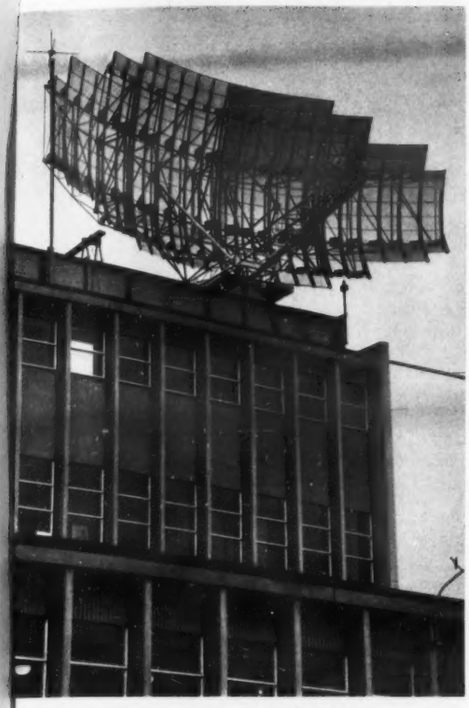
A memory tube for eliminating fixed echoes completes each radar chain, which also includes all units normally used in modern radar systems (STC, FTC etc), plus a logarithmic amplifier chain which can be substituted for the normal chain to diminish clutter.

The system ensures complete cover with a 90% probability of detection (i.e., the aircraft is detected a minimum of 9 times out of each 10 antenna rotations) at distances of up to 55 to 60 miles and a minimum altitude of 33,000 ft (under the least favourable conditions), for a target with a reflecting surface of 118 sq. ft. (average twin-engine aircraft).

The screens and consoles have been designed with particular care, because their characteristics have considerable influence on the performance of the radar as a whole, which they can either make or mar.

Two procedures have been retained: the first is based on consoles of fairly traditional type, although they include all modern refinements. The use of fixed coil displays permits the superimposition of markers, vectors and even alpha-numeric symbols, intended to give the operator all the facilities and information he may need to work the equipment under his control and cooperate with other radar controllers.

The second procedure uses the TMA 403 X scan conversion/storage tube, an ingenious device developed by CSF. This stores the radar image, which is scanned horizontally in the manner of a normal television picture reproduced on a television screen. The radar information presented in this way possesses all the properties of a normal television picture and can therefore be reproduced on a number of screens without undue difficulty or expense. The television



CSF surveillance radar on the roof of Orly area control centre.

image has considerably higher brilliance than a radar image; it is no longer necessary for the operator to work in darkness, and it has been possible to install a receiver of this kind even in the control tower (where luminosity is particularly high, since the room is completely glassed).

The memory of the conversion equipment can be adjusted between a fraction of a second and several minutes, allowing not only the current positions of the aircraft to be shown but also their tracks.

Finally, it is possible to use traditional radio link procedures to retransmit the image to any distance, the techniques in question having long since been fully perfected for commercial television purposes. In particular, it has been possible to relay to Orly and Le Bourget Airports the image produced by the long-range radar of the Paris Area Control Centre and to maintain closer, and above all easier, coordination between the control units concerned.

The two transmitter/receivers of the CSF surveillance radar.

larger projector which would have been very difficult to bed into the existing runway. The combined strength of the lighting, whilst permitting long distance recognition, avoids dazzle at near range, since the projectors are seen as distinct individual lights. In any case it would seem too early to draw clear-cut conclusions about this lighting system built by Olophane.

Air traffic control

Air traffic control at Orly is the responsibility of the French Government, but the Airport authority is responsible for installing and maintaining the necessary systems and bears the cost involved. Within the framework of his overall responsibility for the coordination of all public services concerned in the working of Orly Airport, the General Manager of the Airport authority has administrative control over the air traffic control personnel at Orly, and this division of responsibility has so far worked well.

Airport and approach control are housed in a 60 ft high tower on the east side of the airport, in the same building as the technical equipment for air traffic control.

Airport control is located on the top floor, with the Approach Control Room immediately below it.

The jurisdiction of Orly Airport control includes not only Orly Airport itself but also the military aerodrome of Villacoublay located some 10 miles to the north-west, since aircraft approaching Orly from the west or leaving Orly in a westerly direction inevitably fly past Villacoublay. This arrangement is essential in order to maintain smooth traffic conditions at both airports in safety. The aerodrome of Brétigny, whilst also very close (some 10 miles to the south of Orly), is used mainly for test flights. This precludes its being put on the same basis as Villacoublay, and it was found preferable to employ geographical separation of aircraft between Orly and Brétigny.

The control procedures for arriving and departing aircraft are based largely on the use of radar supported by check points (radio beacons) on predetermined tracks. In particular, a zone of radar control has been established covering the approach sector, into which only aircraft which have been identified and cleared by the radar controller are admitted. There are special arrangements for jet aircraft, designed to avoid their remaining at low altitudes for longish periods, which would be uneconomic. They are separated and guided by radar on to special paths in such a way as to intercept the approach centre line at a greater distance from the airport than piston-engined aircraft, which makes it easier to feed them into the main traffic streams. →→

Control tower at Orly Airport. Far left, the CSF radar and television equipment, whose screen has been fitted with a viewing hood to make it visible in bright sunlight.

Approach control room.

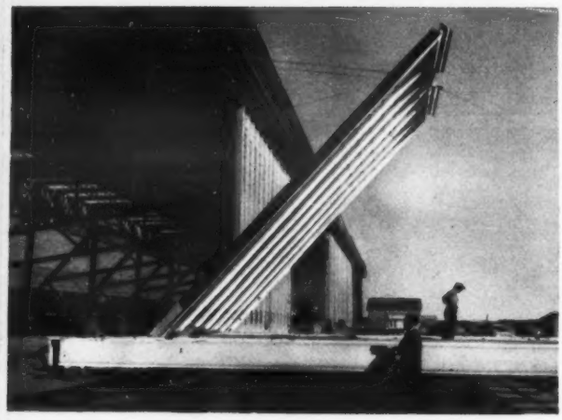
Precision approach radar console at Orly.

Paris-Orly

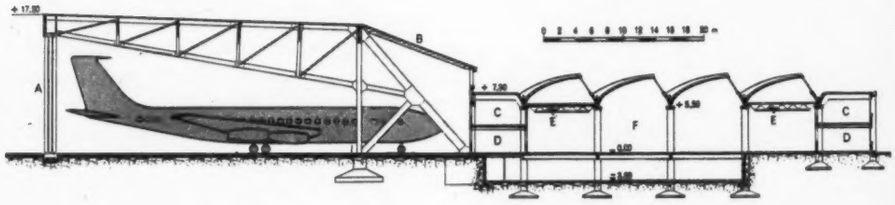
The New Hangar

By Edouard Becker, Paris Airport authority

Born in 1912, Edouard Becker was appointed head of Department 2 at Paris Airport in 1958, with responsibility for planning. In 1949, on the occasion of the Aeronautical Industries Congress, Edouard Becker presented a plan for a hangar on the overhang construction principle and set out its advantages.



Raising one of the doors into position. The three grooves in which the doors slide can be clearly seen.



Section of the hangar and its offices. A – sliding doors; B – window; C – offices; D – stores; E – 5 ton travelling crane; F – workshops.

Since 1954, the airport authority has built five hangars of overhang design—a large one at Le Bourget and four at Orly Airport. Of the latter, one with a frontage of 713 ft and one with a frontage of 535 ft were put into service in 1955, and a third (495 ft) was completed in 1958. As regards the last, Hangar N6, we appreciated from the beginning that aircraft were liable to increase in size in the future, and this justified retention of the overhang principle.

Had it on the other hand been possible to proceed on the assumption that there would be no appreciable change in the future size of aircraft, it would have been more economical to build a "box construction" hangar divided into 175 ft × 165 ft rectangles. The saving effected in this way would have represented 9% of the total cost.

The main dimensions of Hangar N6 are as follows:

Length	990 ft
Depth (from inside edge of doors to rear wall)	174 ft
Clearance	50 ft
Hangar surface area	175,000 sq.ft.

The principal parts of the steel framework are ten main girders triangulated on the Pratt system. A central expansion joint is situated at the centre of the hangar framework.

The roof slopes from front to back at a gradient of 3 in 100, and a large sloping glassed-in window at the back of the hangar facing north runs along its entire length, providing excellent daylight lighting.

The hangar can be closed by means of twelve sliding doors on three parallel sets of rails, each door being 82 ft long and weighing about 66,000 lb; 3.5 h.p. motors operate these doors at a speed of 2 ft/sec, with a device for simultaneous operation of three parallel doors.

In the foreground, Hangar N6 and its offices; behind, to the right, Hangars N1 and N2, built in 1954 and, further right, the old hangars.

Electric light is provided by 288 bright aluminium reflectors with 400 watt bulbs, which yield an average illumination of 200 lux measured in a horizontal plane 10 ft above floor level.

Heating is furnished by one of the airport's central heating installations, the inside temperature being equivalent to +12°C at an outside temperature of —7°C.

The heat is transmitted in two ways, namely by radiation from tubes under the roof, which are provided with reflectors, and by a vertical warm air curtain extending the entire length of the doors. The hangar offices comprise a workshop building, an administrative building and a third building and are contained in a 175 ft × 165 ft rectangle.

The hangar, together with its offices, was designed and built by the Airport authority to the requirements of the two tenant companies, TAI and TWA.

Foam and CO_2 hydrants are installed at the foot of each upright and at the gable ends of the hangar. There is an automatic alarm system which informs the Orly Airport fire brigade the moment use is made of a hydrant, and they are on the scene within a few minutes.

To avoid a fire spreading, the hangar is divided into six 165 ft zones, each corresponding to the parking place of an aircraft. These zones, can be shut off from each other transversally by a double water curtain. In addition, transversal 8 ft deep screens, depending from the roof, prevent the circulation of hot gases.

There are also longitudinal double water curtains, which act as a screen for isolating the hangar offices. This protection is completed by "Monitor" fire extinguishers.

*

Preparation of the ground was started in November 1958 and, less than 15 months later, on January 1st 1961, TAI was able to take possession of part of the hangar buildings. The hangar was finished on January 1st 1960 and the whole building officially opened on June 29th 1960.

The cost of the hangar and offices amounted to 30 million new francs. →

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APRON SURVEILLANCE

Television presents an all-round view of the complete parking area, eliminating the blind spots and enabling the marshalling supervisor to see the number and disposition of aircraft anywhere on the apron.

DATA TRANSMISSION FOR AIR TRAFFIC CONTROL

PASSENGER HANDLING INFORMATION

ARRIVAL/DEPARTURE INFORMATION

FLIGHT SCHEDULE INFORMATION

FLIGHT MOVEMENT INFORMATION

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MET. BRIEFING

DOCUMENT TRANSMISSION

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FLIGHT TESTING

RUNWAY OBSERVATION

APRON SURVEILLANCE

MARCONI

TELEVISION FOR AVIATION

Closed Circuit Television Division

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED

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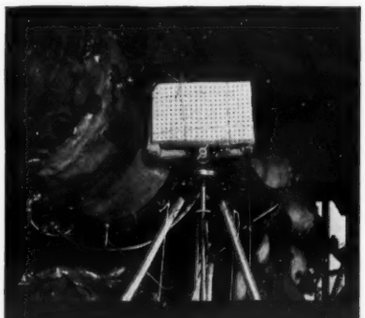

RESEARCH

Observation of after burning in a gas turbine engine at a government research station. This is typical of the many research applications for which television is being used to-day.

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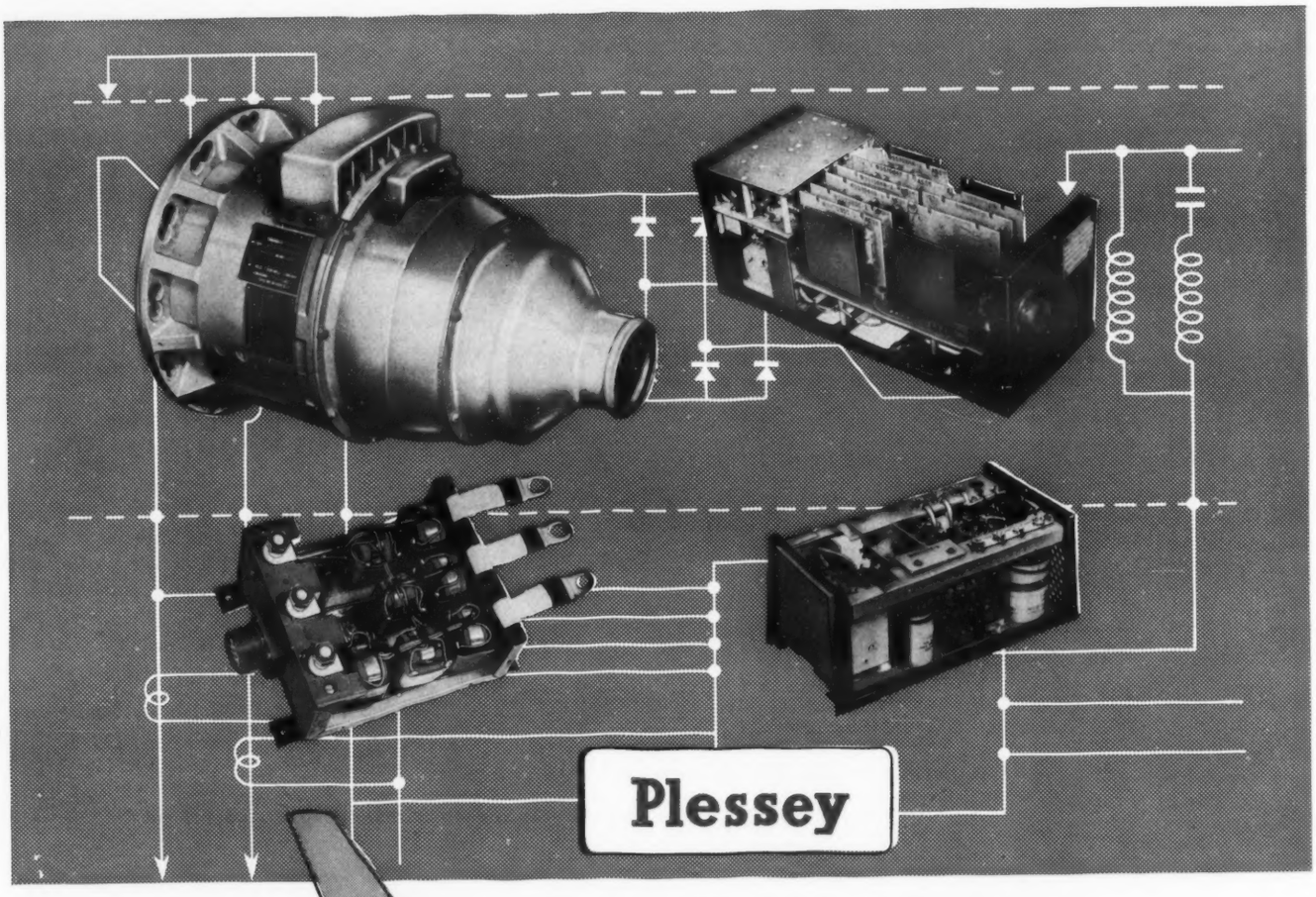

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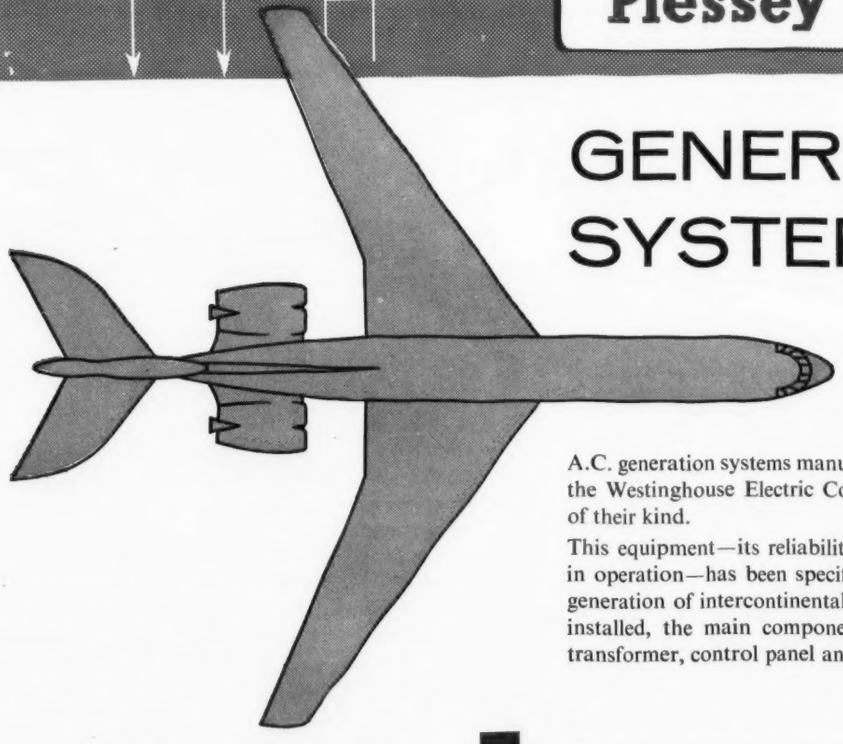

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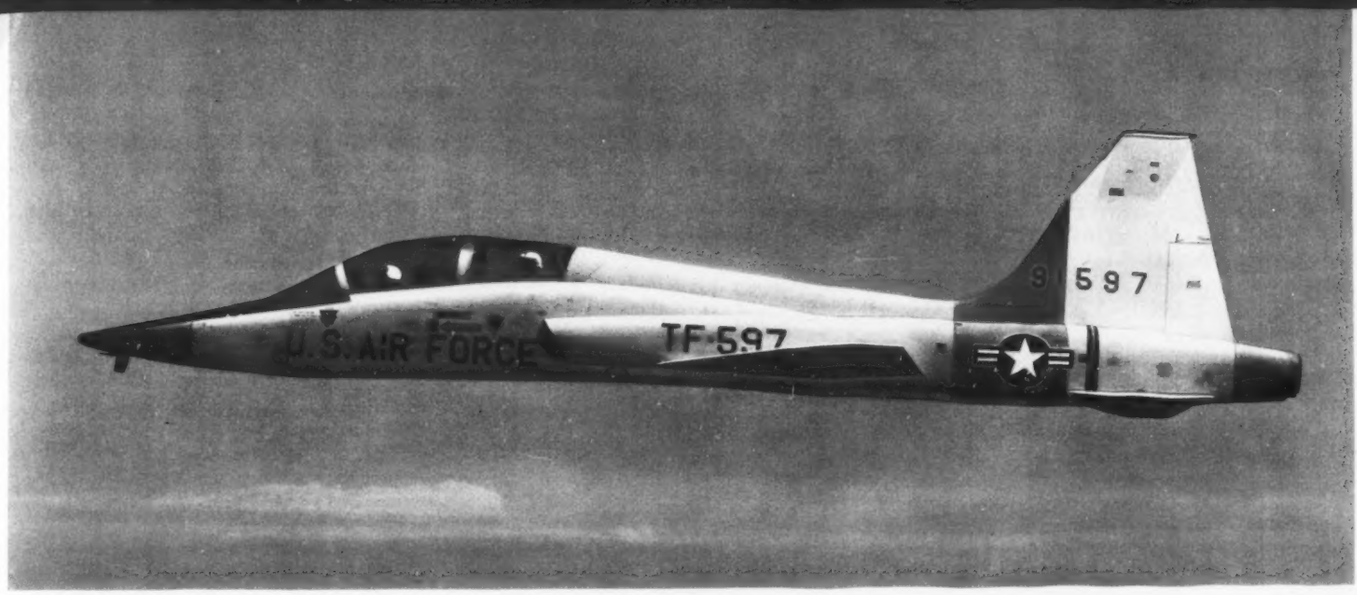


A New Approach to Flight Training

*By Lt. Col. Arthur W. Buck, USAF**

In an age dominated by missiles, we sometimes lose sight of the human element in our military posture. This is evidenced by the fact that, while the USAF Air Training Command increased the number of its missile courses from 4 in 1952 to more than 450 in 1960, the number of pilots graduated by the Command dropped from 5,300 in 1954 to less than 2,000 in 1960.

Yet human skill is more important than ever to ATC. In the constant quest for technological improvement, however, hardware capability will pull ahead of human capability. When this happens, human skills must be brought abreast of the new technical development. This is the task which the Air Training Command faced in the transition from piston to jet aircraft in the period immediately following World War II. Today an identical problem is posed in preparing the USAF student pilot—in subsonic trainers—for the split-second actions demanded in new high-performance fighters, interceptors and bombers.

The need for training aircraft which approximate the performance of tactical aircraft is obvious. A student pilot exposed only to subsonic primary and basic trainers lacks the experience necessary for safe transition to a high-speed combat aircraft. He is not physically and mentally prepared for maneuvers at Mach 1.5 and beyond. He must be taught to think faster, to prepare faster, to plan his moves far in advance.

It was in recognition of this problem, plus the fact that even higher performance fighters and interceptors were on the 1960-1970 horizon, that ATC, in 1953, set forth a requirement for a new aircraft to succeed its existing basic trainer, the subsonic T-33.

The General Operating Requirement was completed in 1956, calling for a "lightweight, economic basic trainer" capable of preparing pilots for operation of "high-speed jet aircraft of the present and the future."

Paralleling these requirements was a study undertaken by Northrop Corp. to determine the causes of mounting costs in manned aircraft systems and to find ways of reversing the trend without sacrificing quality. Subsequently the company began work on a new family of lightweight supersonic aircraft intended to reduce system complexity and cost. In this projected family the Air Force found the qualities it needed for a supersonic basic trainer. A development contract was awarded in mid-1956 for a new aircraft to be known as the T-38 *Talon*.

The T-38 is a two-place, Mach 1.2 aircraft powered by two General Electric J85 afterburning engines at 3.850 lb of thrust each, with a maximum take-off weight of approximately 11,600 lb. Its 7.3 thrust-to-weight

Lt. Colonel Arthur W. Buck, Director of the USAF T-38A operational testing programme.

* Lt. Col. Buck is the T-38 Category III Test Director, USAF Air Training Command.

ratio gives the T-38 performance capabilities comparable to those of Century Series fighters having twice the weight.

The two lightweight engines can lift the aircraft from the ground after a 2,600 ft run, can climb at a sea level rate of 30,000 ft/min, have a ceiling above 55,000 ft, and can produce a maximum speed in excess of Mach 1.2.

To the Air Training Command, these high-performance characteristics mean that the major categories of basic pilot training can now include those techniques (high sink rates, high-altitude supersonic flight, high-altitude formation and navigational problems, etc.) peculiar to Century Series aircraft.

Several other considerations influenced ATC's selection of the new lightweight trainer. The paramount problem facing ATC in the mid-1950s was the gradual loss of logical training sequence. The pilot training began, in Phase I primary, with the single piston-engine Beech T-34, progressing in Phase II to the single-engine North American T-28. The single-engine Mach 0.8 Lockheed T-33 was the basic trainer, and it had served well in preparing the student pilot for flight in the F-86 fighter and the B-47 bomber. But in 1956 the faster, more advanced Century Series fighters and interceptors (North American F-100, Mc Donnell F-101, Convair F-102 and Lockheed F-104) were coming into prominence, heralding a much broader performance gap between basic trainers and combat aircraft.

With the T-33 replacement promised for the early 1960s, and the logical training sequence impaired by accelerating technology, the Air Force elected to modify F-84, F-86 and subsequently F-100 fighters for service as advanced trainers, temporarily filling the gap between the T-33 and the Mach 1 to Mach 1.5 Century aircraft.

Extensive use of modified combat aircraft, however, would be too costly. For example, cost projections indicated that use of the T-38 on a 130-hour training program would produce savings of more than $10,000 per student in comparison to a 160-hour program for the T-33/F-100F combination.

The modified, Mach 1-range combat aircraft, moreover, did not provide sufficient increase in performance over the Mach 0.8 T-33, which ultimately would lead to difficulties in student transition to Mach 2 aircraft. Subsequent replacement of the T-28 with the twin-jet Cessna T-37 narrowed the performance margin between primary and basic phases. This move set the stage for a logical training sequence more compatible with the basic trainer performance promised by the T-38.

The presently projected training sequence in ATC, therefore, is T-34/T-37 (primary), T-38 (basic), and two-place (TF) versions of combat aircraft. Ultimately the T-34 will be phased out. USAF student pilots will then receive 132 hours of training in the T-37, followed by 140 hours in the T-38. The 272-hour total is about 30% less time than is now required in the T-34, T-28, T-33 and F-100F.

The fact that the T-38 *Talon* is the first known supersonic trainer designed for basic training will yield many dividends for ATC. The *Talon*, for example, is the first USAF trainer having performance capabilities in the same range as the tactical aircraft for which the student is being trained. At the same time, the aircraft has the characteristics needed to make it safe for a student fresh from primary instruction. Excellent wing lift, a stable pitching moment throughout the speed range, positive directional stability and aileron effectiveness contribute materially to flight safety.

Because the T-38 program was launched in 1956, its designers were able to take advantage of aerodynamic experience gained in flights of experimental supersonic aircraft prior to that year. Benefits included refinements to the "area rule" fuselage design, elimination of pitchup and inertia coupling problems, and aerodynamic trim designed into the fuselage so as to eliminate control surface trim—one of the first applications of this principle in U.S. aircraft. The new trainer is actually capable of simulating many flight characteristics of various fighters and interceptors.

The T-38 is also the first supersonic twin-engine basic trainer. The two engines, which provide a vital safety factor, permit training in multi-engine operation as a more immediate step toward multi-jet fighters or bombers.

Altogether, the new basic trainer provides training in the three fundamental stages of formation, tactics and instrument navigation, together with multi-engine flight, high-altitude supersonic flight, ground-controlled intercept and all-weather operations. Because of its low maintenance time, it is estimated that the *Talon* can be flown approximately 60 hours per month. A training group equipped with 25 *Talons* can train 140 pilots per year, with each student receiving 140 flying hours.

But as the *Talon* is designed primarily for the student pilot, built-in safety is uppermost. Pilots who have flown the T-38 are enthusiastic about its stability, its smoothness in the transonic region, its functional cockpit, stall characteristics and general ease of handling, all of which contribute to early student confidence and hence to safety.

The extra reliability of two engines is perhaps the most significant safety factor. This reduces the possibility of aborted take-offs, in-flight power failure or electrical system failure. Students can be taught emergency procedures with a higher degree of safety than has been possible in single-engine trainers. Air starts and single-engine flight can be demonstrated safely, an important factor for both instructor and student, for hesitancy and miscalculation during emergency procedures can be dangerous in a high-performance single-engine aircraft. Close mounting of the engines at the rear of the fuselage minimizes the need for trim correction should one engine fail. Carrying its maximum load, with gear and flaps down, the T-38 can take off, circle a field and land on one of its engines.

Structurally, the use of high-strength castings, thin-wall stainless steel, titanium, magnesium and honeycomb construction makes the *Talon* stronger than most contemporary fighters. Fatigue life, landing gear strength and ability to pull g-loads (up to 7.33 g) are all equal to or better than current Mach 2 fighters.

Visibility is excellent for both student and instructor. The rear seat is positioned 10 inches above the forward seat, enabling the instructor to easily detect and override student errors. Vision to either side and downward is unobstructed.

The T-38, which entered the initial phases of operation in March, 1961, has been undergoing flight tests at Edwards AFB since its inaugural flight in April 1959.

The *Talon* is the first aircraft to be tested entirely under the integrated Contractor/USAF Category Testing Concept. The program features three steps:

Category I (Subsystem Development Test and Evaluation) — This phase provides preliminary performance data, stability and control evaluation, and structural verification. Any corrections developing from this phase can be applied prior to delivery of production aircraft. Tests are performed primarily by the contractor, with USAF pilots scheduled into the program as early as possible for customer evaluation.

Category II (System Development Test and Evaluation) — This phase provides extensive systems evaluation, final performance data, and all-weather systems evaluation. It includes military demonstration of the complete system in a realistic environment. Tests are performed primarily by the Air Research and Development Command with minimum contractor participation and extensive Air Training Command participation.

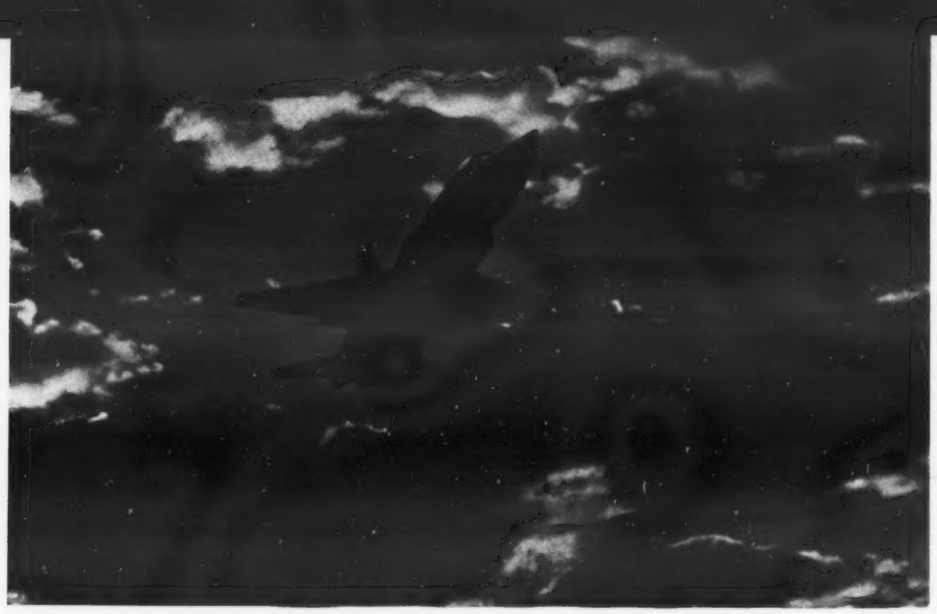
Category III (System Operational Test and Evaluation) — This phase consists of ATC tests and evaluations of operationally configured systems, with all components, support items and personal skills under operational conditions. Tests are performed entirely by an ATC task force at Randolph AFB.

Category I testing of the T-38 is still in progress, with USAF pilots flying 28 of the first 100 flights. Category II was completed in February 1961, approximately a month ahead of schedule. Category III was to begin in March 1961, building to a task force of 28 production aircraft by mid-1961.

In September 1961, training of a 25-student test class will begin at Randolph. Training will be conducted by the ATC task group participating in Category II testing at Edwards. During this phase, which will total 6,300 hours' flying time, a training syllabus for the T-38 program will be verified. Completion of this phase, marking completion of Category III, is scheduled for March 1962, at which time T-38 training will be expanded throughout ATC.

Using development engines, T-38s have achieved Mach 1.22 at Edwards. In initial flights with production engines, the aircraft has reached Mach 1.25 and is expected to reach Mach 1.27. Of particular note is the fact that the *Talon* program at Edwards is perhaps the safest ever conducted with a supersonic jet: no flight accidents have occurred in over 2,000 flight hours.

The T-38 promises to open a new era in the training of USAF pilots. It meets all high-performance training requirements for transition to the most advanced manned aircraft (including Mach 3 fighters and new fighters and bombers now in development) during the next decade. Not only can the *Talon* fulfill this critical assignment, it can do so at comparatively low production and operating costs. ←



"Individual intelligence, initiative, courage and judgment have not been outdated by push buttons and fantastic technical performance . . . The need to maintain the edge of training and leadership honed to its keenest . . . over an indefinite period is perhaps the greatest challenge which the United States Air Force has ever faced." General Thomas D. White, USAF Chief of Staff.

The Northrop T-38 Supersonic Trainer

When, a few years ago, the U.S. Air Force long-range planning staff faced the future and the decade from 1960 to 1970, one pressing requirement became immediately apparent: the need for a new, high-performance jet trainer that could efficiently bridge the ever-widening gap between the USAF's primary training aircraft and the rapidly-advancing vehicles of the space age. The supersonic Northrop T-38 high performance jet trainer was selected by USAF as the answer to that requirement.

The T-38s in production at Northrop's Norair Division have been thoroughly proven in one of the safest flight test programs ever conducted at Edwards AFB. This program began with the aircraft's first flight, April 10th 1959, from Palmdale, California and concluded as the first T-38s became operational at Randolph Field, Texas, last month (March). During that time, over 2,000 flights and more than 2,000 flying hours were recorded by Northrop and USAF test pilots without a single flying accident. Over 150 different pilots, representing the U.S. Air Force, Navy and Army, and the armed forces of several other nations, have flown the T-38s.

The early phases of the flight test program, which ultimately included 14 airplanes, were carried out using prototype General Electric YJ85-1 engines. As the program progressed, however, fully-rated production version afterburning J85-5s went into operation. With these engines, the T-38 has been flown consistently up to 1.27 indicated Mach number. The maximum speed guaranteed to the Air Force is M 1.2. In dives the T-38 has reached 1.5 IMN, and indications are that this figure will probably extend to 1.6 IMN.

The rate of climb is comparable to that of contemporary Century Series fighters such as the F-104. The T-38 climbs at indicated Mach numbers of 0.9 to 0.93. An intensive spin test program carried out first by Northrop pilots and then by USAF test pilots demonstrated that the chances of an inadvertent spin in the T-38 are virtually non-existent.

Landing loads tests to determine the strength of the aircraft were carried out beyond the T-38's designed sink rate limitations without any changes to the structure. Tests were carried out at sink rates of 12½ feet per second, although the maximum design specification at minimum weight was 9 feet per second. Normal landings rarely exceed four feet per second, with the majority of landings falling within the one to two feet per second category. The T-38 has an average glide ratio of approximately 9½ to 1, although it can be flown to simulate lower ratio aircraft.

The flying qualities of the T-38 demonstrated in the flight test program have shown that cross-coupling effects are at a very minimum throughout the flight envelope up to Mach 1.5. Unlike every other supersonic aircraft flying today, in the T-38 there are no abrupt changes in stability throughout the entire flight envelope. Low visibility approaches and landings can be accomplished with a minimum of stress on the pilot, since the aircraft has a turn-radius of only ¾ of a mile at approach speeds.

High performance

A significant factor in the development of the T-38 was the rapid increase of aerodynamic knowledge and performance prediction ability that developed in recent years. As a result of this advancing technology, the problems of stability, control and inertia coupling which were experienced in first generation jet aircraft have been eliminated in the T-38.

The first aerodynamic design objective for the T-38 was complete flight safety. This was achieved by designing around twin-engine reliability, excellent landing approach characteristics, adequate directional stability, good anti-spin characteristics, careful attention to roll coupling, and assurance that no pitch-up occured at any Mach number. A second major design objective was high performance through technology rather than through additional power or any compromise of safety. This objective was achieved through design of a high speed system with good subsonic cruise performance, wide mission flexibility, low landing speeds, short take-off distances, and high rates of climb.

The first T-38 unit has been stationed at Randolph Field Air Force Base since March. Over 2,000 flight hours have so far been logged without incident during the test programme.

Last-minute preparations for take-off on a test flight. The recording equipment is installed in the rear cockpit, in which the pilot instructor normally sits.

These design objectives were met by the use of such aerodynamic principles as supersonic eara rule; a straight, low aspect ratio vertical stabilizer for stiffness, low drag, and good directional stability; and a low horizontal stabilizer. The swept leading-edge wing, with low drag and good stall characteristics, is cambered at the leading edge to prevent tip stall. The cambered forward fuselage allows excellent visibility while still providing low drag. A low stalling speed reduces ordinary landing hazards, and down to stalling speed and below the aircraft is completely controllable. Deceleration from pattern speed to approach speed is made without affecting the landing pattern. Single-engine flight capabilities are improved by the inboard location of the twin-engine power plant, ensuring negligible trim changing. The structural load limit factor of the aircraft is 7.33 g.

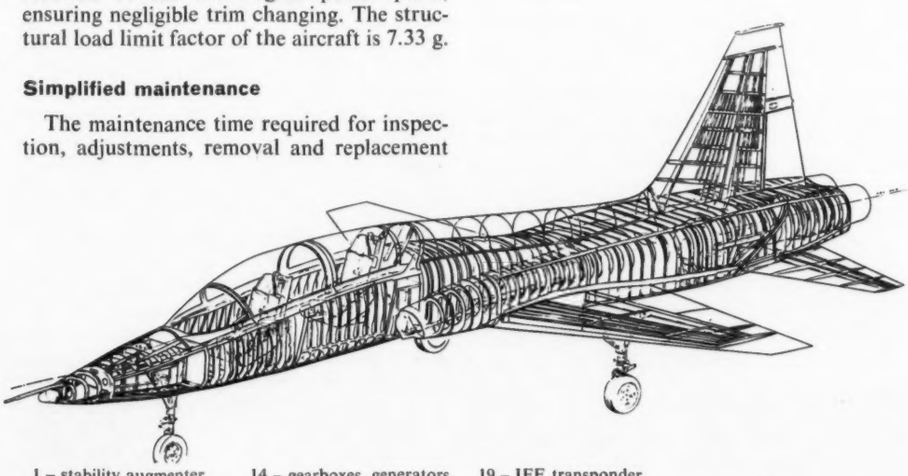
Simplified maintenance

The maintenance time required for inspection, adjustments, removal and replacement of T-38 components has been kept to a minimum. Components have been located where they can be easily reached from the ground without the use of special work stands or ladders. Approximately 25 percent of the fuselage surface consists of access doors or panels. The simplicity of maintenance has been achieved by specifically designing it into the airframe. In general the maintenance effort is about eight direct man-hours per flight hour.

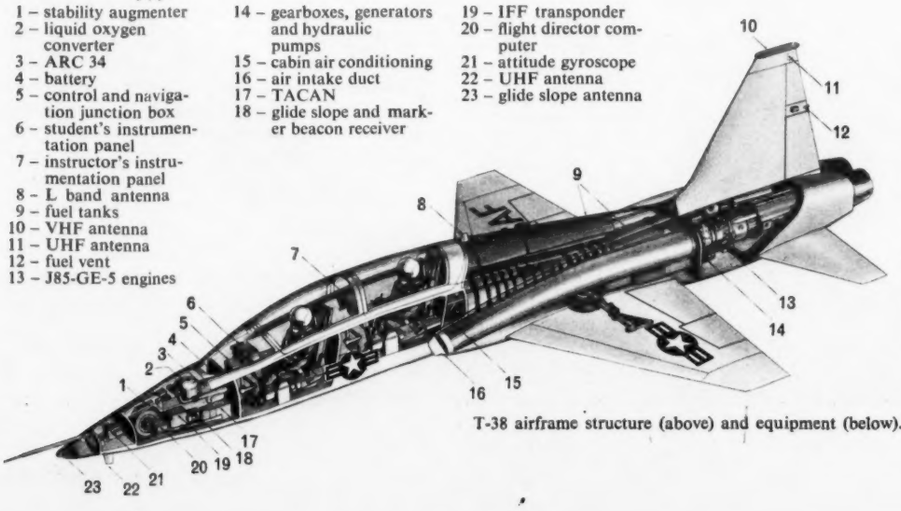
Easy inspection and maintenance of engines has been achieved by the design of both the engines and the engine installations. Engine bays in the aircraft provide a compact installation. Removal and installation of engines is facilitated by a built-in overhead track and roller arrangement in the bays. The lightweight, easy-to-handle engine assemblies can be individually removed and interchanged with a minimum of tools, and horizontally split casings simplify inspection and repair of turbine and compressor sections.

Engine-driven accessories are mounted on the airframe, not on the engine. An integrated power package consiting of a two-speed, automatic-shifting gear box, an alternating current generator, and a hydraulic pump, is mounted on the airframe below and forward of each engine, and is driven by the engine through a drive shaft. This power package can be removed as a unit without removing the engine, and in turn permits engine removal and installation without disturbing any connections in the electrical or hydraulic systems of the aircraft.

Each engine has an independent, self-contained oil supply and lubrication system with a pressure gage in each cockpit. Either engine may be started by low pressure air supplied from a ground source. Both cockpits contain air-start switches for making in-flight starts of a windmilling engine.



1 – stability augmenter
2 – liquid oxygen converter
3 – ARC 34
4 – battery
5 – control and navigation junction box
6 – student's instrumentation panel
7 – instructor's instrumentation panel
8 – L band antenna
9 – fuel tanks
10 – VHF antenna
11 – UHF antenna
12 – fuel vent
13 – J85-GE-5 engines
14 – gearboxes, generators and hydraulic pumps
15 – cabin air conditioning
16 – air intake duct
17 – TACAN
18 – glide slope and marker beacon receiver
19 – IFF transponder
20 – flight director computer
21 – attitude gyroscope
22 – UHF antenna
23 – glide slope antenna



T-38 airframe structure (above) and equipment (below).

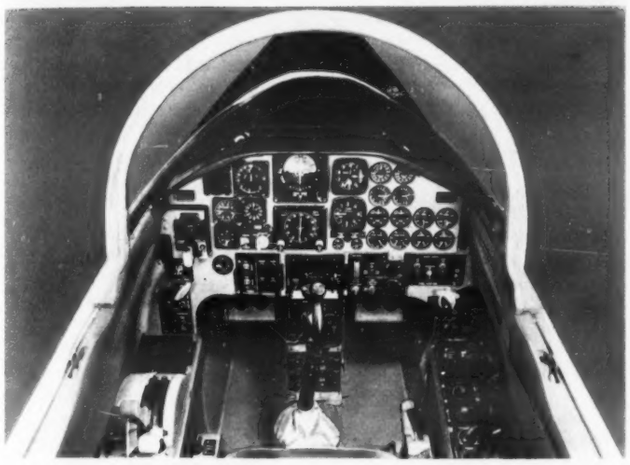
Subsystems

A simple fuel supply system requiring minimum pilot attention during flight has been designed for the T-38. Each engine receives fuel from a separate independent fuel supply, but in an emergency a crossfeed connection is available, controlled by a single two-position switch in the front cockpit.

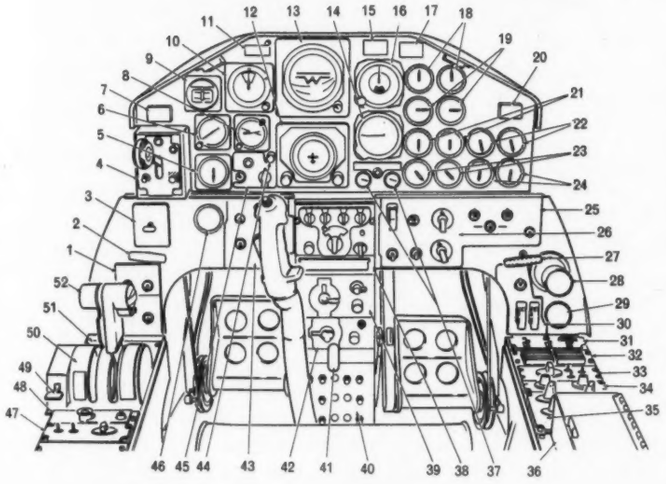
Fuel is pumped to the engines by electric pumps. In case of pump failure, a bypass check valve around each pump ensures automatic gravity feeding fuel flow at all altitudes up to 20,000 feet. The system operates satisfactorily under flight attitudes of 90 degree dive, 90 degree climb, 25 degree sideslip, and limited inverted flight.

Each fuel tank has several bladder cells made of rubber-impregnated nylon fabric laced to the internal structure of the center fuselage. Each tank holds approximately 300 U.S. gallons. Crossfeed and pump switches are in the front cockpit, and indicating lamps showing the position of the switches are provided in the rear cockpit. Fuel quantity indicators and low-level warning lights are provided in both cockpits. Under normal flight operations, no fuel sequencing is required.

Hydraulic power of 3,000 p.s.i. for the T-38 is supplied by two engine-driven hydraulic pumps, each with a separate circuit and a separate reservoir pressured by air from the engine compressors. Each system provides half the power required by the primary flight control surfaces (ailerons, rudder, and horizontal tail). The left engine system also supplies all the power needed by the landing gear, the nose wheel steering system, the stability augmenter, and the speed brakes. If either system fails, the other will automatically provide adequate flight control power. While both engines are working, the aircraft hydraulic system continuously supplies power for fully powered flight control. If both engines fail, ram air will generate enough hydraulic



◀ The design and instrument layout of the T-38's cockpit correspond with those of a modern combat aircraft. All indicators are mounted on a panel only 10 inches high for easy monitoring and reading. Picture shows the front cockpit (trainee pilot); it has more instrumentation than the rear cockpit, which contains only the more important items of equipment enabling the instructor to control the aircraft himself if need be.



1 – engine start panel and fast slave switch
2 – alternate landing gear release
3 – landing and taxi light switch
4 – landing gear control panel
5 – cabin altimeter
6 – accelerometer
7 – left fire warning light
8 – aircraft clock
9 – standby compass
10 – Mach/airspeed indicator
11 – radio call
12 – horizontal situation display
13 – vertical situation display
14 – vertical speed indicator
15 – master caution light
16 – altimeter
17 – canopy lock light
18 – tachometers
19 – temperature exhaust indicators
20 – right fire warning light
21 – nozzle position indicators
22 – oil pressure indicators
23 – fuel flow indicators
24 – fuel quantity indicators
25 – fuel control panel
26 – air conditioning and pressurization control panel
27 – canopy jettison "T" handle
28 – air outlet
29 – liquid oxygen quantity indicator
30 – electrical control panel
31 – oxygen regulator
32 – warning lights panel
33 – transponder set control
34 – coder group control panel
35 – cockpit lighting panel
36 – map case
37 – hydraulic pressure indicators
38 – communication panel
39 – TACAN (tactical air navigation panel)
40 – circuit breakers
41 – rudder adjustment "T" handle
42 – ILS (instrument landing system) panel
43 – intercommunications and radio transfer panel
44 – marker beacon light
45 – navigation mode selector panel
46 – flap position indicator
47 – stability augmenter panel
48 – take-off trim panel
49 – flap control
50 – power quadrant
51 – stowage box
52 – engine throttles

power to maintain flight control for glide and landing.

Electrical power for the T-38 is supplied by two independent alternating current systems, by a direct current system, and by an external power receptacle for connecting a ground power source to the aircraft. Primary 115/200 volt, 3 phase, alternating current for lighting, instruments, and electrically operated equipment is supplied by two identical engine-driven generator systems. During normal operation, each of the two 8 kVA generators carries half the load; if one fails, the affected loads are automatically switched over to the other generator. A 28 volt direct current system obtains power through a transformer-rectifier in the alternating current system. For engine starts when ground power is not available, a 24 volt, 5 ampere-hour battery and an ignition vibrator are provided for ignition and essential instrument excitation. Battery power is also used for emergency lighting of the instrument panels.

Electronics

The integrated communication, navigation, and identification radio equipment of the T-38 includes an AN/ARC-34X command communications set, which provides short range two-way voice communication from airplane to airplane or airplane to ground. A total of 1,750 UHF frequencies are available from 225 to 400 megacycles. Any frequency in this range may be selected manually, and any 20 preselected frequencies may be set up for rapid and easy selection during flight.

Tactical air navigation (TACAN) is provided by an AN/ARN-65 radio navigation set, giving a visual indication of the range and

The Engines of the T-38

In December 1954, General Electric received an order from the USAF for the development of a super-light high performance turbojet, and by November 1955 its Small Aircraft Engine Department was already in a position to put the main elements of this turbojet engine on a test-rig. As early as January 1956 the first complete assembly began its series of tests under the designation J85.

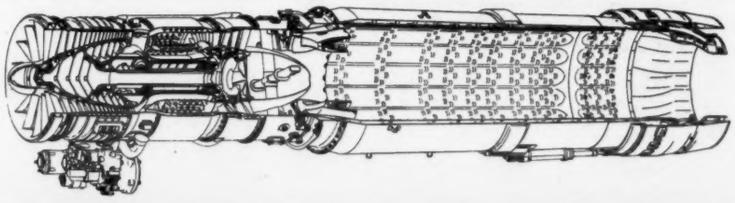
The first version of this General Electric gas turbine, equipped with a seven-stage compressor, was intended for propulsion of the USAF GAM-72 *Quail* decoy missile. Later, a long-life version was developed for use with supersonic aircraft and this, with its eight-stage compressor, is now in production.

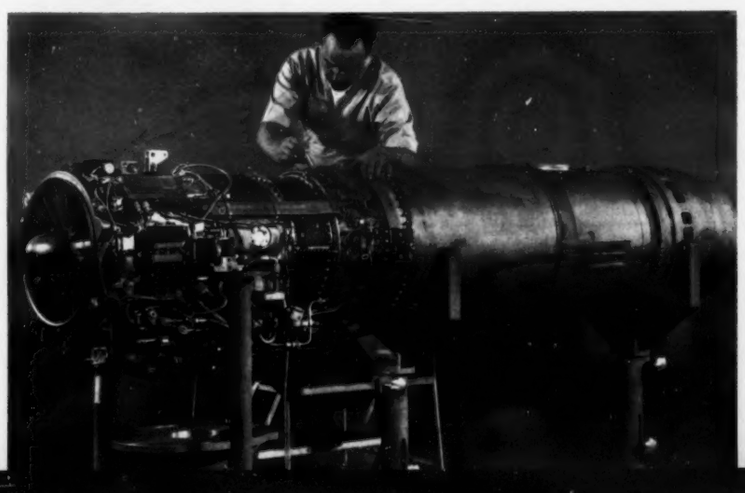
Flight trials with the missile version (J85-7) in mid-1958 were followed in March 1958 by the J85-5 version for the Northrop T-38 and N-156F supersonic aircraft, first of all in a special test pod under a Convair F-102 supersonic fighter and later in the two Northrop aircraft just mentioned. So far, more than 23,000 hours ground testing and test flying have been recorded. Recent tests have demonstrated the suitability of the afterburner version for speeds of up to Mach 2.

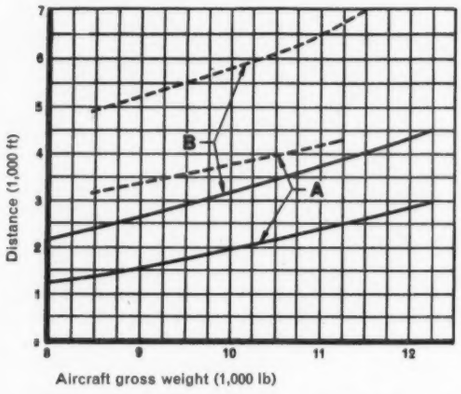
Weight	525 lb*	Normal continuous rating	2,050 lb
Length	104.2 in	Specific fuel consumption	
Maximum diameter	20.2 in	at military power	
Pressure ratio	6.5 :1	with afterburner	2.2 lb/lb/h
Airflow	42.5 lb/sec	without afterburner	1.01 lb/lb/h
Military rating		at normal	
with afterburner	3,850 lb*	continuous power	0.98 lb/lb/h
without afterburner	2,500 lb*	thrust-to-weight ratio	7.3*

* Recent GE tests, reflecting anticipated J 85-5 performance growth, with engine weight increased to 538 lb, have yielded military ratings of 4,100 lb with afterburner, 3,050 lb without afterburner, and thrust-to-weight ratio of 7.6. No verified data are yet available on how these engine performance increases will affect aircraft performance.

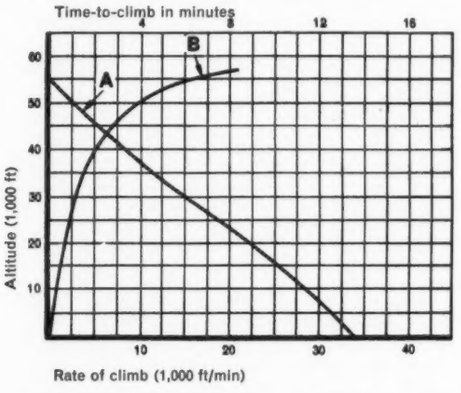
The basic characteristics of this engine are an eight-stage axial compressor with a two-stage air-cooled turbine. The engine has three main bearings, an annular combustion chamber and variable inlet vanes with de-icing system. For starting and acceleration, these vanes are operated by compressed air tapped from the third stage of the compressor. The compressor stator casing is of horizontally split design and, to facilitate routine maintenance, the annular combustion chamber is provided with inspection ports.



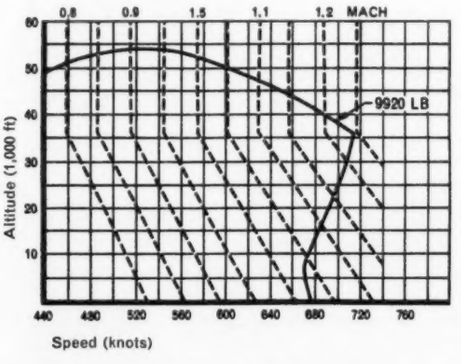




Take-off and landing distances as a function of aircraft weight. The take-off distance (continuous curves) is for maximum power at 20° flaps, the landing distance for 45° flaps. A – ground run; B – distance to clear 50 ft.



Rate of climb (curve A) and time-to-climb (curve B) as functions of absolute altitude, at maximum engine power. The time-to-climb curve takes account of the reduced weight owing to fuel consumption. Take-off weight is taken as 9,920 lb throughout.



Mach/altitude graph for the T-38; the continuous curve applies for a gross weight of 9,920 lb and maximum engine power.

bearing of a selected ground station. This equipment operates in the 962 to 1,213 megacycle range on a channel-sharing basis with the IFF equipment. A total of 126 channels are available. An AN/APX-46 interrogator-responder supplies IFF/SIF (identification friend or foe/security identification feature) coded replies to interrogation signals from ground stations.

Localizer and glide slope information, showing aircraft lateral and vertical deviations from the proper approach path, are shown by an AN/ARN-58 instrument landing system as bar deflections on the attitude director indicator of the flight director system. A space-referenced gyro-stabilized platform, sensitive in the pitch and roll axes, senses aircraft attitude.

The AN/AIC-18 interphone system provides communication between crew members. When a headset and microphone are plugged into an external receptacle in the nose of the aircraft, the equipment also provides communication between the ground crew and the two cockpits. The system uses transistorized audio amplifiers with separate control panels in each cockpit.

Cockpit layout

The T-38 would by no means fulfil its function as a universal trainer if its cockpits did not closely simulate those of high performance combat aircraft. They have accordingly been designed for the greatest possible safety, convenience, and comfort of crew members. The T-38 is ordinarily flown from the front cockpit, but duplication of controls and essential instruments in the rear cockpit enables the instructor to monitor the information necessary for safe flight, and when necessary, to fly the aircraft himself. A tricycle landing gear powered by the utility hydraulic system is likewise controlled from either cockpit. The nose wheel is equipped with a steering system controlled by rudder pedal action and also powered by the hydraulic system. An emergency landing gear system allows gear extension without hydraulic or electrical power.

Visibility over the forward fuselage is outstanding. The instructor, seated 10 inches higher than the student, has an excellent forward field of vision, with unrestricted side vision for both crew members. Cockpits are 30 inches wide, enabling full-pressure suits to be worn. Seats in both cockpits are adjustable vertically.

Maximum lighting effectiveness in the cockpits is provided by integral white instrument lighting and by white floodlighting. The white lighting system enables pilots at night to distinguish colours on instruments and maps. Two emergency floodlights automatically receive power from a battery if their normal alternating current source fails. Each cockpit contains a map light which can also be used as a hand light for signalling or other purposes.

Each cockpit has its own transparent canopy enclosure which can be independently opened, closed, locked, and jettisoned from either inside or outside the aircraft. The canopies are ejected by gas-oparated thrusters. When either canopy is not down and locked, red warning lamps are lighted in both cockpits. When both canopies are safely down and locked, a rubber seal on each canopy is automatically inflated with air from the engine compressor.

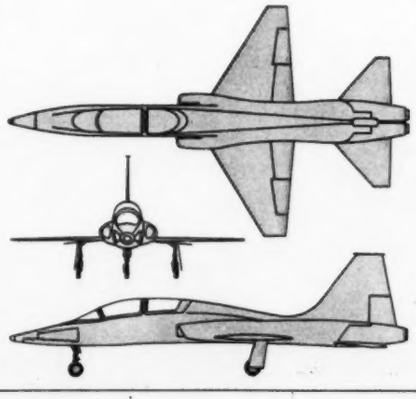
Forward of the front canopy is a one-piece windshield, hinged at the front to provide access to instruments. Between the two cockpits is a second windscreen, which fully protects the rear cockpit from wind blast after jettison of the front canopy. The ejection seats are actuated by rockets and make safe "climbout" possible even in the vicinity of the ground.

Automatic cockpit pressurization and temperature control for the conditioning of cockpits and electronic equipment are provided by a system which also defogs and defrosts the windshield and canopies and inflates the canopy seals. The system uses bleed air from both the engine compressors. Cooling of the heated air is accomplished by a heat exchanger with ram air as the cooling agent. The controls are in the front cockpit.

*

All USAF Air Training Command bases now used or programmed for basic single-engine training are adequate for T-38 operation. In other words, the re-equipment of training units with the T-38 does not involve major changes in the present set-up and ground support organization of Air Training Command. ←←

Dimensions		Sweep at 25% chord	24°
Length	44 ft 2 in.	Dihedral	0°
Height	12 ft 11 in.	Incidence	0°
Wing span	25 ft 3 in.	Track width	10 ft 9 in.
Wing area	170 sq.ft.		



Weights	
Empty weight	7,146 lb
Take-off weight (full fuel, 602 U.S. gal.)	11,600 lb ap.
Design take-off weight (50% fuel)	9,592 lb
Landing weight (with reserves for 20 minute loiter)	8,425 lb
Powerplant*	
Two General Electric J85-5 turbojets	
Weight of each engine	525 lb
Thrust-to-weight ratio	7.3
Performance both engines	
Guaranteed speed	Mach 1.2
Sea level rate of climb	30,000 ft/min
Service ceiling (100 ft/min rate of climb possible)	55,200 ft
Take-off roll (at gross weight)	2,600 ft
Landing speed (8,425 lb landing weight)	127 knots
Landing roll (8,425 lb landing weight)	3,225 ft
Single engine	
Maximum speed	Mach 0.95
Sea level rate of climb, undercarriage and flaps retracted (gross weight, max. engine power)	6,100 ft/min
Sea level rate of climb, undercarriage and flaps down (gross weight, max. engine power)	1,680 ft/min
Service ceiling (100 ft/min rate of climb possible)	42,200 ft

* see box previous page

Northrop T-38

Flying the Talon

A Pilot's Impressions

*By Richard L. Sweeney**

Pilots in the basic phase of modern training programs are concentrating hard on the new subjects they are encountering—navigation, formation and tactics, instrument flying and the like. Flying an aircraft which has a high degree of inherent stability, controllability and maneuverability makes it considerably easier for them to assimilate these essential new elements in the training program. The Northrop Corporation's T-38 supersonic trainer is "on their side" from the start; it does not need to be conquered, then constantly watched for signs of rebelliousness.

Having flown a number of jet trainer and operational fighter aircraft (Temco TT-1, Cessna T-37, Lockheed T-33, NAA F-100, Convair F-102), the writer had a basis for comparison and evaluation of the T-38 both as an aircraft and as a trainer.

The aircraft flown for the evaluation was USAF T-38 No. 59-1603. It was the first production aircraft to fly, using the first production General Electric J85-GE-5 turbojet engines. The aircraft had made only its initial production test flight and, as a consequence, the primary task was to fulfil the test program card.

Named *Talon* by USAF, the T-38 is a low-wing, twin-engine aircraft with tandem cockpits. Wings are of medium-low aspect ratio, employing 25 deg. sweep at the quarter-chord, a straight trailing edge and a thickness ratio of 4.8 percent. Ailerons are small span, deep chord for supersonic efficiency. Air speed brakes are fuselage belly mounted.

The *Talon's* flight controls employ cable and pushrod connections between the pilot's controls and the valves which control the hydraulic surface actuating cylinders. Since there is no actual "feel," springs are used in the rudder and ailerons, and a spring and bob weight in the elevator system. This arrangement provides increasing stick force per g in the pitch axis. The trim system moves the primary controls against the springs and weight, rather than employing auxiliary surfaces.

Engine-driven accessories are mounted on the airframe rather than on the engine; thus accessories can be serviced or changed without removing the engine, and vice versa. Each engine drives its own two-speed automatic shifting gearbox, and each gearbox drives an alternating current generator and hydraulic pump. A single engine is capable of meeting flight requirements for prime propulsion and safety of flight systems. As a further measure, even windmilling engines after a double flameout provide sufficient hydraulic power for the flight controls.

Exterior walkround inspection of the T-38 is completely simple and straightforward.

The author before his test flight in the Northrop T-38 *Talon*.

Inspection is for general condition and appearance of visible parts. There are no "acceptable leak rates" in any system, and presence of any fluid apart from the dirt and grease of normal operations indicates trouble. Only three sight gages need to be checked: brake hydraulic reservoir, and flight control and utility system hydraulic reservoirs.

Cockpit layout of the T-38 is exceptionally good from a pilot's viewpoint. Primary flight instruments have been arranged in the T configuration of airspeed, attitude and altitude, with the horizontal situation display under the attitude indicator. There are no controls aft of the pilot's shoulder in either cockpit, in fact the furthest back item is the takeoff trim switch which is on the left console and is pushed to set controls for takeoff trim position prior to leaving the ramp.

There is no clutter, either of controls or panel gages. Engine instruments are located on the right, in such a way that gross position impressions are satisfactory for general flight conditions, yet significant departure would be readily noticed.

Ground starting of the J85 engines is accomplished with low pressure ground-supplied air to both engines, or low pressure air to the right engine. The procedure is simple; start switch on GROUND position at 6 percent r.p.m., throttle to IDLE at 10 percent r.p.m. while monitoring EGT, fuel flow and oil pressure rise.

*

Norair Chief Test Pilot Jack Wells rode the front cockpit on the flight, but most of the flying was done from the rear seat, the exceptions being several short intervals when unplanned checks appeared indicated on certain items in the aircraft. The profile of the flight called for afterburner takeoff and climb straightaway to 48,000 ft, followed by a sampling of characteristics and qualities at altitude, a descent to 36,000 ft for a speed run in the Air Force Flight Test Center super-

* The author, a graduate of the California Institute of Technology and a member of the Experimental Test Pilots Association, was for many years an associate editor of Aviation Week and has flown a large number and wide variety of aircraft, ranging from the Cessna 172 to the Boeing 707. *The Editors.*

sonic corridor, descent then to approximately 15,000 ft for general medium-altitude airwork sampling, then two touch-and-go landings while checking the aircraft's ILS and TACAN equipment, with a third landing to complete the flight.

During taxi, nosewheel steering is operated through rudder pedals. Hydraulic steering is engaged by a stick button which is pressed to engage, then must be pressed again to disengage. The airplane steers well, is not oversensitive, and has a small turn radius. Taxi usually is accomplished at idle power. Visibility from the rear seat, which is 10 in. higher than the front seat, is exceptional in all flight phases.

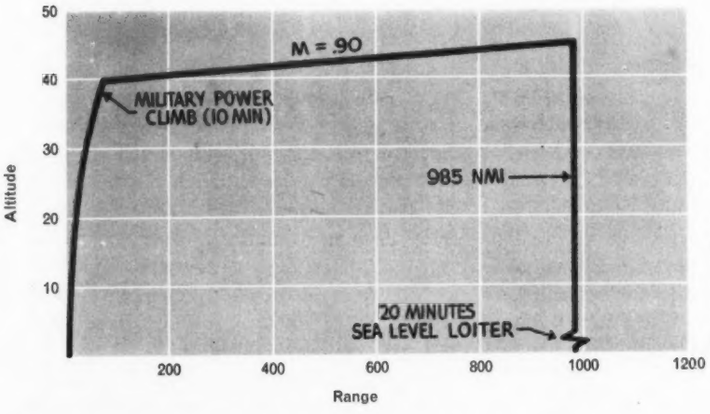
When AF 603 received takeoff clearance, the engines were advanced to military (100 percent r.p.m.) power, EGT and other gages checked, then throttles advanced over the cams into afterburner position. Ambient temperature was slightly below standard on the day of the flight, both on the ground and at altitude, and the combination of takeoff weight and thrust available with production engines and afterburners gave the airplane a nearly one-to-one thrust/weight ratio. Brakes were released as the burners were turned on—the aircraft cannot be held against the burners with brakes alone.

Takeoff technique calls for rotation at 140 knots IAS, gear retraction after liftoff and flap retraction from takeoff position (approximately 25 percent) as soon as practicable. Roll distance approximated 2,500 ft from brake release to liftoff. Initial acceleration of the airplane could be disconcerting with the burners on if one has flown only the usual, slow-accelerating jet aircraft. There are few operational aircraft which even approach the acceleration yielded by the almost-unity thrust/weight ratio. It is planned with the T-38 that students will make initial takeoffs at military power for a few flights, until they are familiar with burner operation and the accelerations it produces.

After cleanup, the aircraft is accelerated to 0.90 indicated Mach number (IMN) for standard afterburner climb, which is held to 30,000 ft. The IMN is allowed to rise to 0.93 between 30,000 ft and 40,000 ft, and is held from there upward. The *Talon* requires a definite nose-up attitude to hold the climb schedule. Some 25 deg. are required, decreasing to the order of 18-20 deg. above 35,000 ft.

Climbout of AF 603 was timed from brake release to 32,500 ft at approximately 2½ min. This was the first such climbout of a production article from brake release straightaway to altitude at a high gross weight. It can be truthfully said that the airplane's surprisingly good performance resulted in a departure from the planned climb schedule. During the climb, the indicated Mach number was higher than would normally be expected for the attitude being held. To reestablish the recommended climb schedule, at 43,500 ft the aircraft nose was pulled up very abruptly. At this point, the left afterburner blew out and the engine flamed out. A check later in the flight showed some malfunction in the static side of 603's airspeed system, which had not shown up during the first production flight. Later it was established that at the altitude and indicated airspeed at which the burner blew out, the actual Mach number was outside the normal operating limits envelope; it was a tribute to the T-38 that the right burner stayed lighted during pullup.

The airplane was nosed over and dived to 30,000 ft, and a relight was made at 250 kt IAS. Both engines were checked out for normal operation in afterburner, after which the burners were shut off. At 30,000 ft some turns were made with induced high accelerations, up to 3 g, to sample accelerated stall warnings. These proved to be mild airframe buffet which gave more than adequate warning of the stall condition. The airplane was not reefed in all the way, control pressure was released and the stall broken after initial clear buffet was obtained.



Mission profile for a typical navigation training flight of the T-38A. Altitude in thousands of feet is shown above range in nautical miles. After a ten-minute military power climb, the aircraft can fly at high altitude for nearly 1,000 nautical miles and still have enough fuel reserves for a 20 minute sea level loiter. For this operation the take-off weight is 11,600 lb.

The *Talon* was put through a fairly slow aileron roll, a natural and easy maneuver for the aircraft. Control response was excellent, and no great amount of rudder pressure was required to hold reasonable directional control. Following the roll, the aircraft was climbed to 36,000 ft and a run made in the Air Force Flight Test Center supersonic corridor. After 2½ min in afterburner in the corridor run, the aircraft reached 1.25 IMN.

Following the supersonic run, permission was requested and granted to use the AFFTC dive area. The dive was ended by a normal pullout and extension of dive brakes, which adequately demonstrated their efficiency; no significant longitudinal trim change was noted. Most of the flight was made with stability augmentation systems turned off; the writer feels that they are not absolutely necessary, even at supersonic speeds. Following the dive test, Wells flew the *Talon* through the front half of a Cuban Eight, holding a constant 4 g acceleration throughout the pullup. The aircraft flew through smoothly, with out any apparent trim change longitudinally.

As a result of more time spent flying with the burners on than anticipated, the *Talon* was returned to Palmdale for the ILS-TACAN checkouts which were on the required flight test card, and for touch-and-go landings. Since this was a production flight test, accomplishment of the prescribed tests came first, with any evaluation flight work being secondary.

Carrying out the requested ILS test procedure brought the airplane to a position, at the inner marker, considerably higher than would have normally been the case. To sample the *Talon's* landing qualities, it was elected to land the airplane from the bad initial position. Holding the recommended final approach speed of 150 kt IAS, the T-38 with full flaps and gear down proved no problem to land easily from the abnormally high final approach position.

After a completed touchdown, the flaps were repositioned and afterburners lighted to get airborne again as quickly as possible. Some 200 ft past the point where burners were turned on, the airplane was rotated and became airborne. To avoid exceeding gear and flap speeds afterburners were then turned off. For the second touch-and-go, a completely ordinary and standard circuit pattern for jet aircraft was flown. In this approach, the T-38 demonstrated excellent handling qualities through final approach, flare and touchdown.

Once a pilot is accustomed to the high performance available to him and is able to make proper use of it, the T-38 should prove to be a very worthwhile tool for initial pilot training in the basic phase. ←→

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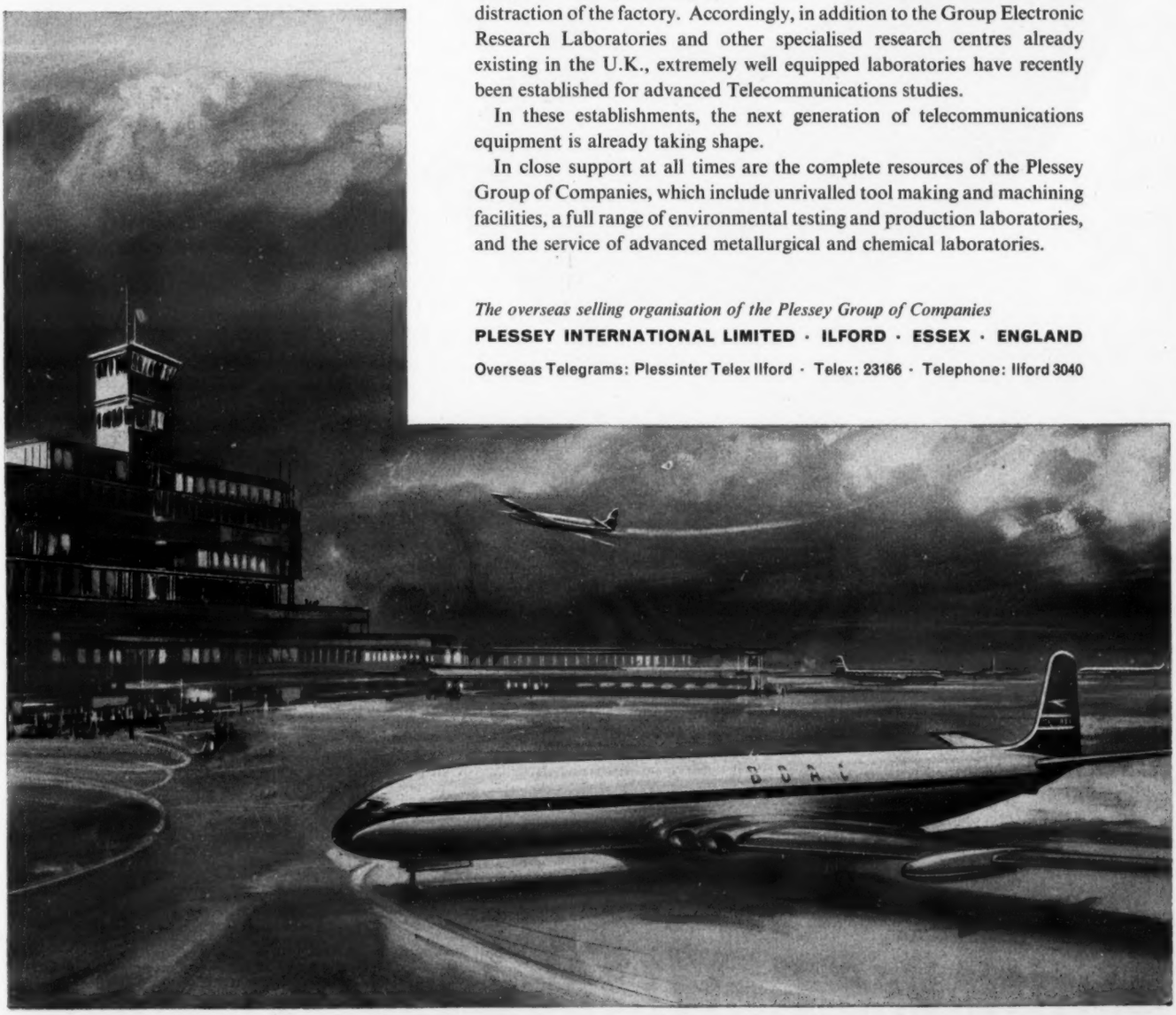

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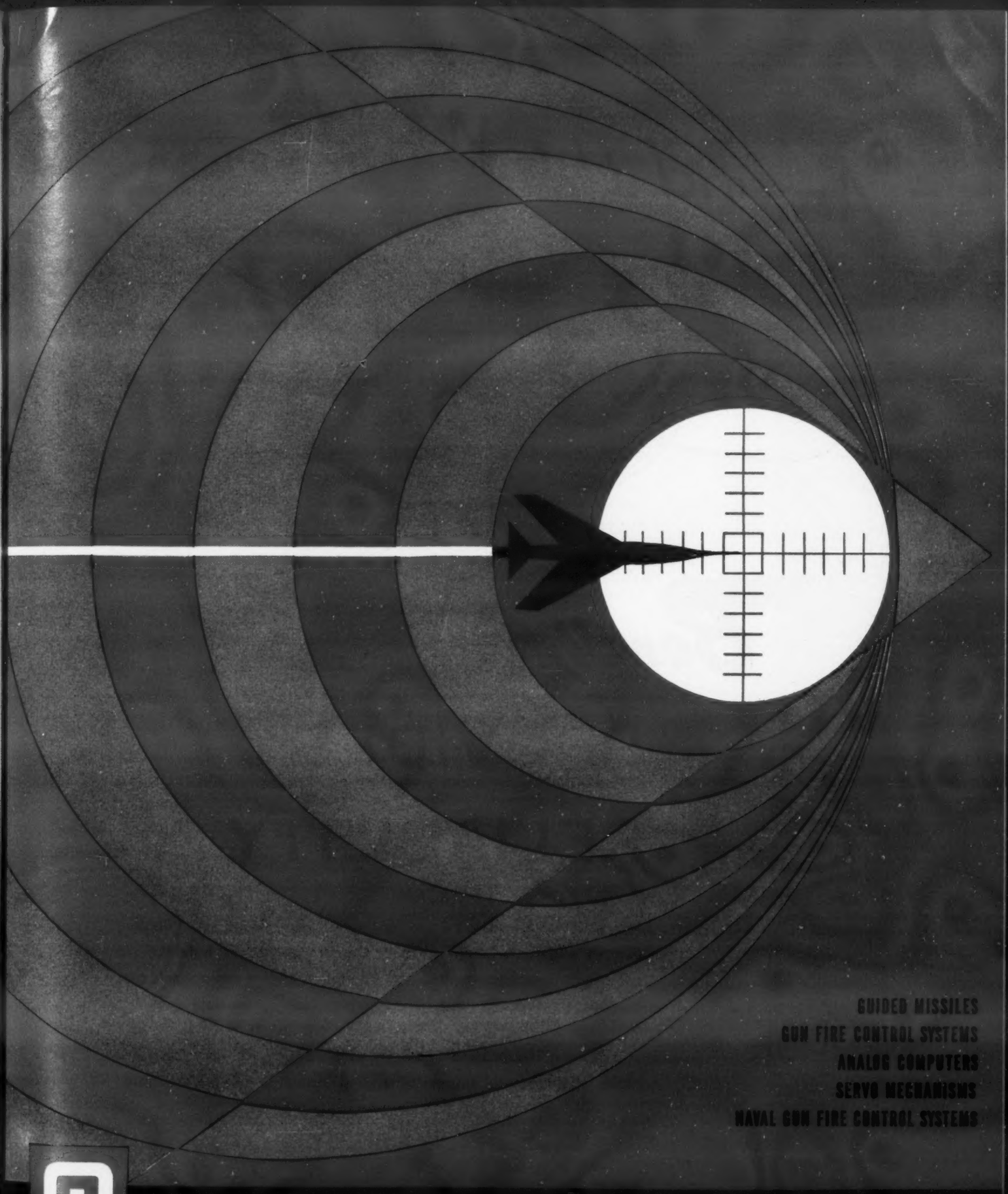

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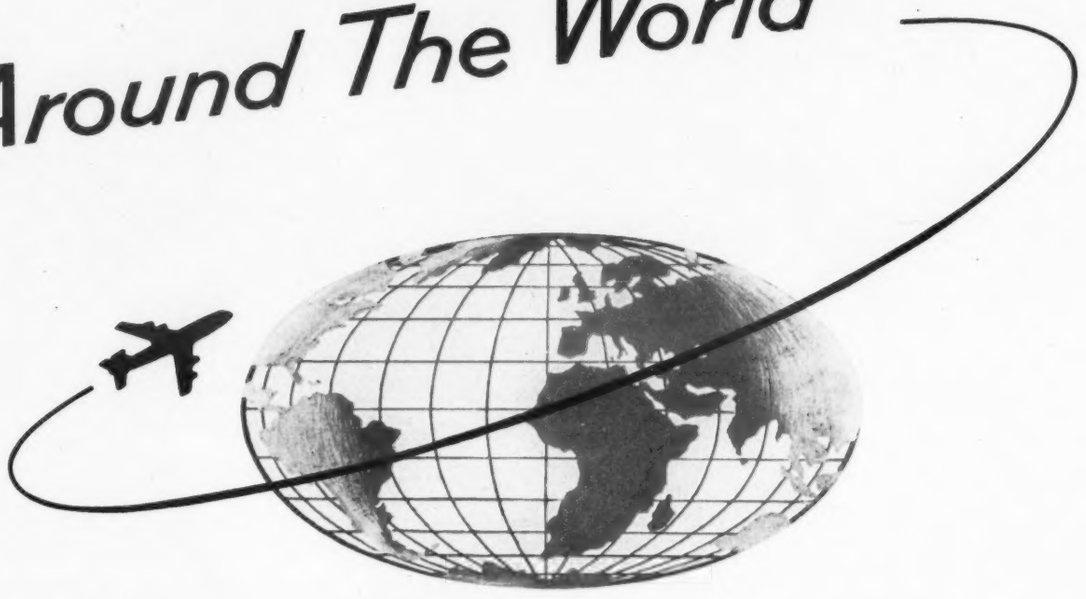

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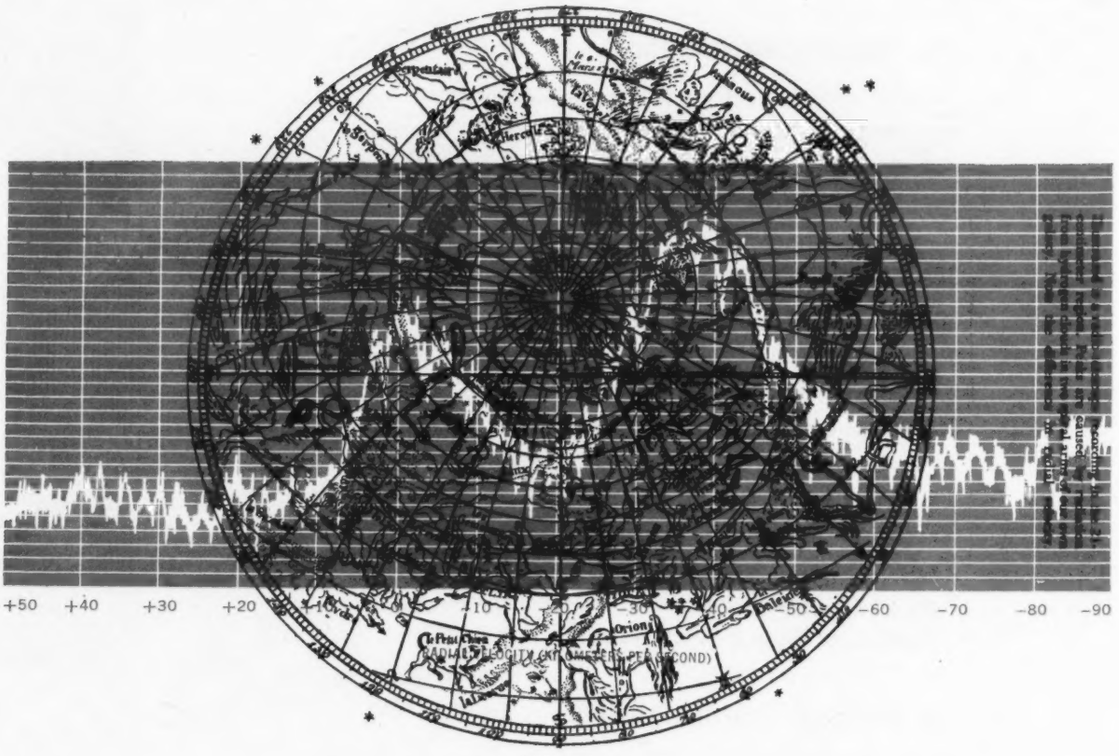

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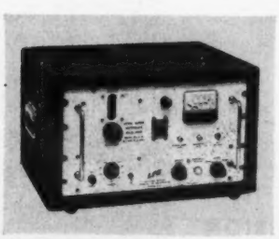

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15,000 feet above the Farnborough crowd, test pilot Bill Bedford threw the red Hunter two-seater trainer into a spin. Falling 10,000 feet in fifty seconds he corkscrewed 12, 13, 14 times — then regained perfect control.

" You saw for yourself " he said, " how hard it was to get into a spin, you have to be really brutal. But in training, we have got to be able to teach pilots how to spin and how to get out of a spin — just in case."

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Hydrofoil Craft of Today and Tomorrow

By Dipl. Ing. K. Büller, Lucerne

Hydrofoil boats are vessels, the hulls of which are lifted out of the water, as speed increases, by so-called underwater wings and moved forward in this position. In this way, both the drag and the effect of the waves are to a large extent neutralized, always provided that the size of the waves does not exceed the dimensions of the boat. The wings, profiled similarly to those of an aircraft, are joined to the hull by supporting struts. Underlying the shape of the wings are aerodynamic and hydrodynamic laws with special reference to the conditions which arise when tilted flaps and profiles move in the boundary between two media, namely air and water. Since however, additional complications are introduced by the waves, the hydrodynamics of the free water surface are basically more difficult to deal with than the theory of aircraft or of fully submerged submarines, both of which move in a single medium.

The fact that water is about 800 times denser than air enables underwater wings to be of substantially smaller dimensions than aircraft wings, this despite the lower speed. Disregarding for the moment the effects of the free water surface, wings and profiles can be treated in accordance with the principles of aerodynamics. This leads mainly to thin foil surfaces, capable of carrying high static loads and requiring a correspondingly high number of supports, which in turn means increased drag and a reduction in the lift-drag ratio. In the higher speed range—for foil ships this means around 60-80 m.p.h.—the dimensions and shape of the foil must also take account of cavitation.

Cavitation is roughly similar to the phenomena occurring with aircraft wings in the sonic speed ranges. The cavitation of propellers and wings can be explained by the fact that static low pressure arising at the top surface of the profile drops to vapour pressure and leads to the formation of bubbles. These bubbles wander in the higher pressure zone, i.e. in the area of the rear wing edge, where they collapse, and damage is caused by the water.

Until a short time ago, it was thought that this cavitation limit would not be exceeded, but now so-called supercavitating profiles for water propellers and wings have been developed in the USA which, at good degrees of mechanical efficiency, are capable of use beyond the speed limits which have existed until now. Further problems do, however, arise in this connection. If excessive drag is to be avoided, wings intended for high speeds must have very small dimensions and extremely thin profiles, in some circumstances making it essential to use expensive methods of construction and to build in expensive materials e.g. titanium. In the case of military hydrofoil ships the cost factor is unimportant, and the difficulties can accordingly be overcome; as far as civil hydrofoil boats are concerned, however, each case has to be considered on its merits and other solutions found.

In determining the cavitation limit and the permissible lift coefficients in connection with it, attention must be paid to so-called orbital velocity in the water particles of the wave, which is equivalent to a rotating movement of the water and thus leads to changes in the angle of incidence of the wing.

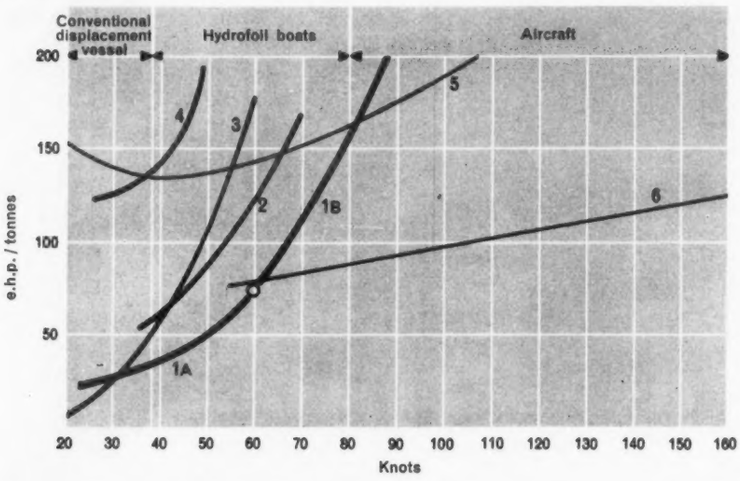


Fig. 5. Specific power for various vessels (e.h.p./tonnes) versus speed. 1A – subcavitating foil boat; 1B – supercavitating foil boat; 2 – V-chine speedboat; 3 – conventional displacement vessel; 4 – air-cushion boat; 5 – helicopter; 6 – fixed-wing aircraft.

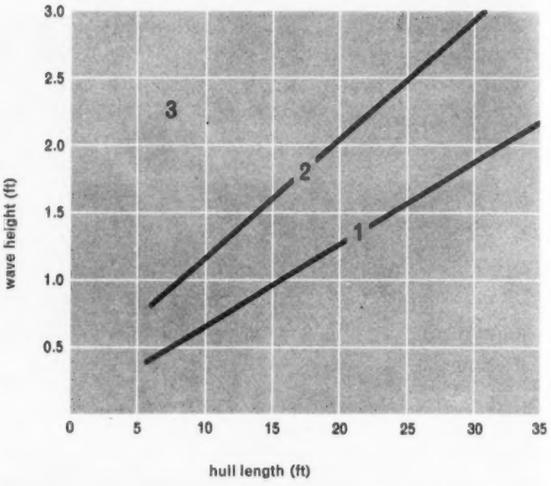


Fig. 6. Seagoing quality of a foil boat vs. length of hull. 1 – limit of wave height at full engine power; 2 – limit of wave height at reduced speed but with hull still emerged; 3 – range of wave heights at which the boat can only travel submerged.

In the early stages of its development, the hydrofoil boat gave rise to a large number of different construction methods and patented ideas, which recall the curious shapes of the first aircraft. This variety in construction arose from the early effort to meet difficulties of stability in pitch, roll and constancy of depth, and can be explained by the very modest state of knowledge at the time concerning the hydrodynamics of the wings at the free and moved water surface.

The hydrofoil boat systems which are here under discussion and of which diagrams appear in *Figs. 1-4*, are as follows:

1) The boat illustrated is characterized by its surface-piercing V-foils which may vary according to their shape and arrangement at the bow or the stern. Adequate pitch and roll stability and elevation stability are achieved by wing parts which penetrate the water surface. When the boat executes a banking movement, stabilizing forces arise at the submerging and emerging wing tips. The Supramar boats, built on the so-called Schertel-Sachsenberg system, belong to this group.

2) In this system the boats have fully submerged foils at the stern. Stability is achieved with the aid of additional wings or bodies which glide on the water's surface. V. Grunberg experimented with similar boats in France in the twenties, and lately this system has been used by Aquavion.

3) In this group, the foils are arranged in the form of ladders, stability being maintained by the submerging and emerging of individual foils, as in the case of 1 above. In 1918 Graham Bell was concerned with development of boats of this kind, as was the Royal Canadian Navy a few years ago.

4) These are boats with fully submerged foils, the load, shape and arrangement of which can vary, but which in any case are without inherent stability. This stability must be achieved automatically or by electromagnetic sensors which regulate the angle of incidence in response to the surface of the water. A further improvement in the performance of hydrofoil boats is to be expected from this type of construction, since the wings are removed from the influence of the water surface and subject to orbital movement on a small scale only, which diminishes as the wing gets further from the water surface.

The most important hydrofoil systems and layouts

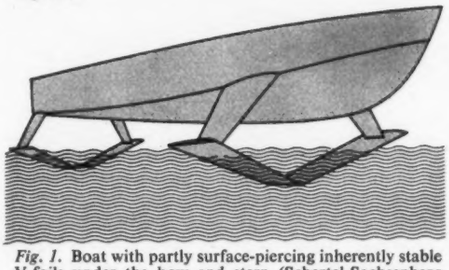


Fig. 1. Boat with partly surface-piercing inherently stable V-foils under the bow and stern (Schertel-Sachsenberg System).

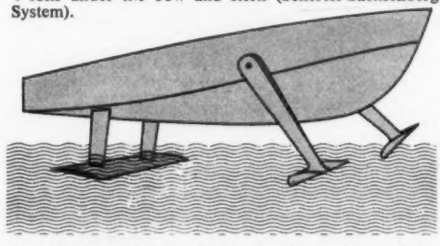


Fig. 2. Boat with fully submerged foils under the stern and stabilizing floats under the bow.

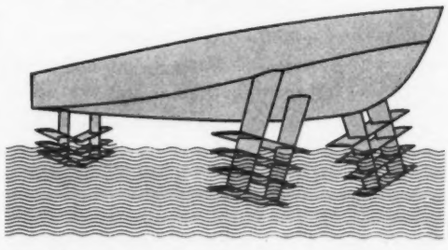
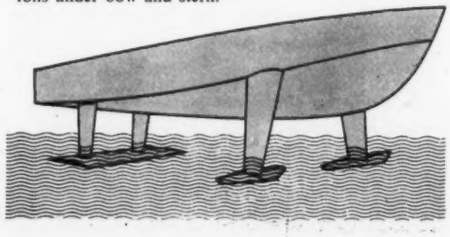


Fig. 3. Boat with inherently stable foils arranged ladder-wise under bow and stern.

Fig. 4. Boat with fully submerged non-inherently stable foils under bow and stern.



As the wing is no longer exposed to aeration, the serious aeration problems facing the constructor of wings which penetrate the water's surface do not arise. However, deeply submerged wings generally require rather long supports, which, besides causing constructional difficulties, increase the drag. The stabilization devices so far developed are on the lines of the automatic flight control systems used in aircraft, but such installations are both costly and subject to disturbance. Supramar is therefore developing a new wing with quasi-inherent stability for boats of this type.

As already mentioned, in the case of the foils which penetrate the water surface or approach it, there exists the danger of aeration. This phenomenon is produced by the pressure on the top side of the foil and may result in instability in the wing. To meet this danger, those parts of the foil lying near the water surface are provided with "aeration-proof" profiles.

Fig. 5 shows the specific power requirement of a foil boat of some 300 tons displacement versus speed, the same relationships being likewise shown for conventional vessels, in order to facilitate comparison. From this, it can be seen that at a certain speed range hydrofoil boats must be more economical than other equally large and fast means of transport.

As compared with other fast ships, hydrofoils exhibit lower power requirement, still higher speed, particularly good seagoing quality (*fig. 6*) and less wave formation. They reach a speed about three times that of conventional vessels and can accordingly carry three times as many passengers over the same route during the same period of time with the result that, as experience to date has shown, they are competitive with all conventional coastal vessels. Their disadvantages are considered to be their greater draught when moving in the water and the bulkiness of their

side wings in berthing. It has however meanwhile been established in practice that berthing operations are not impaired. Certainly, in the case of larger vessels, it will not be possible to circumvent the high tilt of the wings and the associated construction and weight demands, as otherwise shallow berthing, docking, and also cleaning marine growths from the wings, will become difficult. As in the case of aircraft, the hydrodynamic efficiency of the wings is also dependent on a faultless surface (smoothness). For this reason, the wings of foil boats must be cleaned every 4-6 weeks, according to the marine growth conditions in the operating waters; this cleaning can be carried out by means of divers or in a dock.

Although the idea of the hydrofoil boat, whose godfather was the aircraft, is old, and the first vessel of this type appeared in public nearly 60 years ago, it is only in the last 20 years that hydrofoils have reached the stage of technical and commercial maturity. A number of foils was built in Germany during the war but it was only in 1952 that, starting in Switzerland, the principle began to be exploited commercially, since when development has been steeply increasing.

From press reports and patent specifications it is known that in 1887 Count de Lambert demonstrated on the Seine a boat equipped with foil-like structures, which were supposed to lift the vessel and reduce drag. Really successful fully emerging hydrofoil boats however were not built until the Italians Forlanini (1906) and Crocco. These boats are said to have attained speeds of 45 m.p.h. However, these first experiments, although very promising, did not lead to any actually usable hydrofoil boats. This may have been partly due to the fact that the intention at the time was to use the underwater foils in water aircraft to replace the floats. As a result of increased starting speed, increase in surface loads as well as insurmountable aeration and cavitation difficulties, work was stopped.

As far as the ensuing ten years are concerned, the hydrofoil boat experiments of Ricaldoni and Guidoni in Italy and the cavitation investigations of the Americans Richardson and Curtis should be mentioned. It is noteworthy that the pioneer of the telephone, Alexander Graham Bell, also concerned himself with hydrofoil boats, using Forlanini's system as a basis. In 1919, together with Baldwin, Bell constructed a 5 ton vessel, driven by 350 h.p. aircraft engines with propellers, and the boat attained speeds of nearly 75 m.p.h. These developments were inhibited not only by cavitation phenomena but also by the as yet unmastered problems of stability in the seaway, and attempts were made in the twenties to meet these difficulties by a combination of foils and glide surfaces. But the vessels developed according to this method were saddled with the defects of both types—the cavitation of underwater wings and the sensitivity of glide wings to waves. The modern development of the hydrofoil boat began in Germany in the thirties, with the experiments of Freiherr von Schertel and Prof. Tietjens and the associated construction activity of the Sachsenberg shipyard. In fact, in the period up to 1945, nine different types, with displacements of 1-60 tons, were built and tested for the German Navy. Although their military use undoubtedly entered into consideration, these boats served predominantly for experimental purposes.

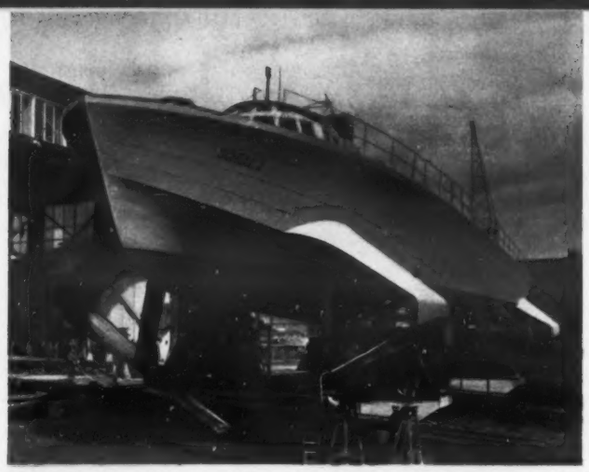
Technical Data on Hydrofoil Craft Built on the Schertel-Sachsenberg System

Type	Year of Construction	Overall Length (ft)	Purpose	Maximum Speed (knots)	Maximum Power Output (e.h.p.)	Construction Material of Hull
TS.1–6	1942	39.0	Military and Police (German Navy)	39	380	Steel
VS.6	1943	55.8	Minelayer (German Navy)	47	1,400	Steel
VS.8	1944	104.7	Tank Transporter (German Navy)	45	4,000 (2 Diesels)	Aluminium
TK	1948	83.3	Speedboat (Soviet Navy)	47	5,000 (2 Diesels)	Aluminium
PT. 10	1952	46.6	Passenger Vessel (30 passengers)	46	540 (1 Diesel)	Wood
POT. 3	1954	34.8	Police Boat	31	150	Aluminium
PT. 21	1955	66.0	Passenger Vessel (60 passengers)	43	1,300	Aluminium
PT. 20	1955	67.6	Passenger Vessel (72 passengers)	40	1,350 (1 Diesel)	Aluminium
PT. 50	1958	91.2	Passenger Vessel (140 passengers)	40	2,700 (2 Diesels)	Aluminium
PT. 27	1958	69.9	Ferryboat (60 seats)	40	1,350 (1 Diesel)	Aluminium
PT. 90	1962	117.5	Passenger Vessel (240 passengers)	53	8,500 (2 Gas turbines)	Aluminium

Based on the experience gathered by some of its staff in Germany between 1936 and 1948, Supramar A.G., a Swiss Company founded in 1952, started work. This post-war development, carried out with the cooperation of Frhr. von Schertel and of a Swiss group, was successful and paved the way for the mature passenger vessels of today. The first recipient of licence production rights, the Cantieri Navali Leopoldo Rodriguez of Messina and Gusto of Schiedam, succeeded in building and bringing into service about 30 hydrofoil boats in the space of five years, and meanwhile Supramar has granted licences to other shipyards, for instance the Westermoenwerft in Norway. Further concerns in Japan and Germany will now follow. There is little doubt that, but for this successful development in Switzerland, the hydrofoil boat would probably have again been forgotten, at least for a time.

The relatively quick development of the foil boat in the last few years is the more remarkable as neither Supramar nor the holders of licence production rights receive any Government support, and furthermore as, until very recently, naval and shipping circles viewed hydrofoil boats with scepticism.

PT. 10, the first hydrofoil passenger vessel in the world, built at Stansstad, Switzerland.



In the second world war the VS 8 tank transporter was built at a shipyard in Hamburg-Harburg. Length 105 ft; maximum speed 45 knots.

The P.T 20 Standard type transport foil boat is in service in the Mediterranean, in Japanese waters, off the Venezuelan coast and off the North West Coast of the USA.

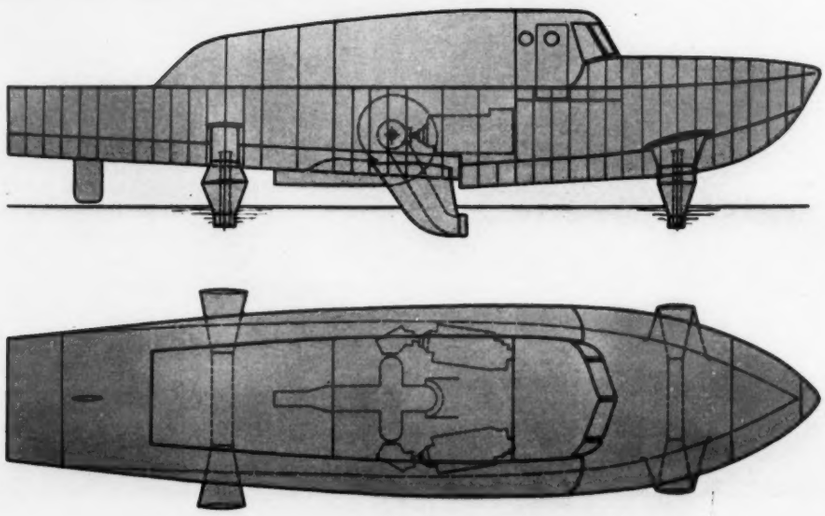
The Soviet *Meteor* foil boat for 150 passengers has for some months been regularly plying the Volga between Gorki and Ulyanovsk and attains cruising speeds of 40 knots.

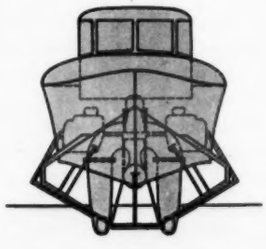
Apart from the USSR, it was only in the USA that shipping authorities and naval circles supported the use of hydrofoil boats and accordingly passed the word to the aircraft industry to look for a new field of application in this sphere. In Soviet Russia, besides the hydrofoil passenger vessels already in use, boats of the *Raketa* class (carrying about 70 persons) and of the *Sputnik* class (150 persons), as well as still larger vessels, are expected to come into operation in the next few years over the whole river and lake traffic system. As for the USA, the Maritime Administration has recently placed an order with the Grumman Aircraft Engineering Corporation for the development and construction of a vessel with a displacement of 80 tons and a speed of 70 knots.

The American aircraft industry sees in the foil boat a welcome addition to its building programme, especially considering the decline in military aircraft construction. Super-fast and super-large craft are under development, which will probably have more significance as military vessels than for civil purposes. A first US naval hydrofoil ship, the joint creation of the Bureau of Ships and Boeing, will shortly be completed, and this vessel, intended for anti-submarine work, should herald the era of military use of hydrofoil craft. This first ship will have a displacement of about 110 tons and a speed of 50 knots, but the U.S. Navy is said to be already planning the construction of larger and substantially faster ships of this type.

When an American 10-year plan, which foresees the building of even ocean-going vessels of this kind (1,000 tons displacement, 100 knots, nuclear propulsion of 52,500 h.p.) was under discussion, it was the shipbuilding industry, with its conservative attitude, which was held responsible for the lagging development of the foil boat.

In looking at this tale of woe, one cannot help being reminded of the principle of Archimedes, initiated in the 3rd Century B.C. but not put to use until 1800 years later, when in about 1600 a shipbuilder first applied this law in his calculations.





Three-view drawing of a foil boat developed shortly after the war for the Soviet Navy and equipped with a piston-engine driven water ejection turbine. This vessel was the project of a German design office at the Rosslauer-Sachsenberg Shipyard.

Meanwhile there have been considerable changes in shipbuilding. Although at launchings and on similar occasions it is customary to speak of an "exemplary development in shipbuilding," in fact it is clear that decades have passed since the vessel of conventional construction reached a state of perfection which, for physical, technical and commercial reasons, can hardly be further improved on. The conventional craft will therefore probably in future also follow the current state of technical development, and will no longer be marked by any increase in speed, but by the completion and modernization of the propulsion units and internal installations, as well as by the application of the latest refinements in hydrodynamics. As is well known, this stagnation in the development of ships is due to the fact that every further increase in maximum speed must be paid for by an enormous increase in motive power, which is not a commercial proposition. The hydrofoil boat, based on the utilization of hydrodynamic lift forces, offers the only possibility for shipbuilding to break the stalemate. The fact that in the last five years the hydrofoil boat has given convincing proof that it is a practical proposition will undoubtedly have far reaching effects on shipping, especially coastal and island traffic.

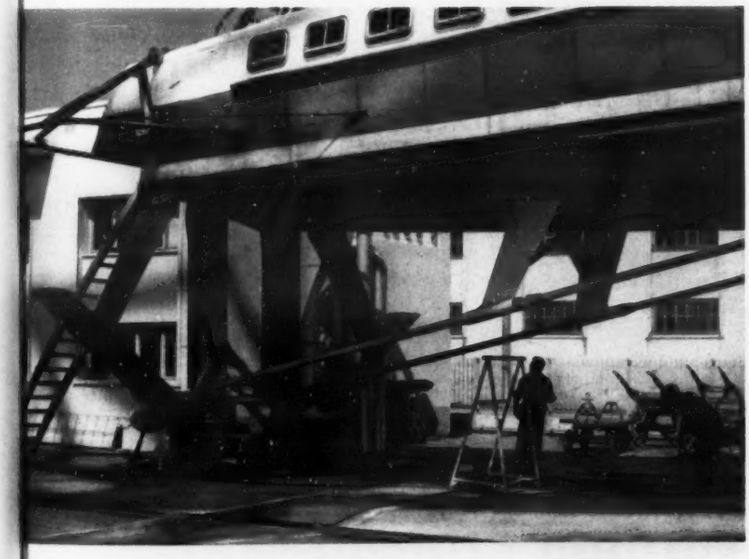
In addition to movements of passengers in coastal and inland waters, in which hydrofoil boats have shown themselves far superior to the convential vessels, such boats also lend themselves to use by police, customs and pilot services. Furthermore, they can be used profitably in industry in conditions where workers and materials have to be moved quickly, e.g. for oil production in the coastal waters of Venezuela. The valuable assistance which hydrofoil boats can render in the transport of perishable goods, especially in tropical waters, should also be mentioned.

On the strength of its experiences to date, Supramar is in a position to draw a fairly clear picture of the present applications for hydrofoil boats. As regards the future, special endeavours will have to be made towards a further increase in speed, an improvement in seagoing quality and an increase in the useful load.

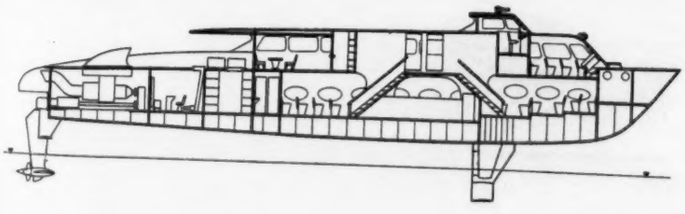
What size hydrofoil boats will reach is, for the time being, still an open question. If one forgets military uses and confines oneself to commercial considerations, it seems that, in the present state of technical knowledge and research, the hydrofoil boat will for the present hardly reach, let alone exceed, a displacement of 1,000 tons. The largest hydrofoil boat so far built was produced during the war and had a displacement of some 80 tons. A boat at present under construction in the USA will have a displacement of 80 tons and is expected to attain 70 knots. The vessels currently in development at Supramar, with a displacement of some 120 tons, are designed for a maximum speed of 53 knots. In the coming years, Supramar will lay down a still larger type for 550 passengers with a displacement of 250 tons. Equipped with 2 gas turbines of altogether 35,000 h.p., this boat will attain a maximum speed of 70 knots. As regards boats already mentioned and those of the future, one should be able to count on a payload amounting to 25-35% of the full displacement. Ocean crossings with a boat of this type are, however, ruled out by the large fuel consumption, but this obstacle will perhaps be overcome later on by a nuclear propulsion system.

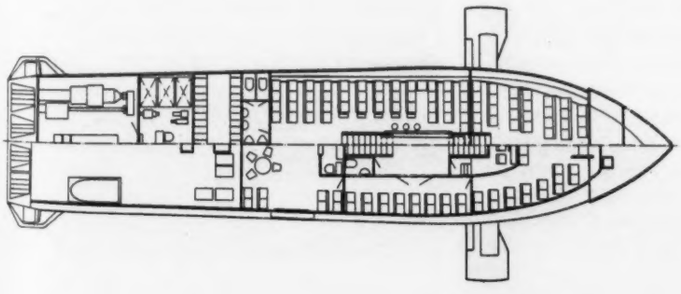
From the hydrodynamic, technical transport and construction points of view, the hydrofoil boat occupies a position midway between aircraft and ship. The question as to whether as a general rule only shipyards should build hydrofoil boats or whether, as seems the case in the USA today, the aircraft industry should take them up, cannot yet be answered, depending as it does on what lines the further development of these new vessels will proceed. As long as it is only a question of building normal boats in relatively small quantities, as have been already built by shipyards of various sizes, the aircraft factories should not be competitive in price. This position may of course

Bow foils and supporting struts of the PT.50. The boundary fences on the upper side of the foil are so-called air barriers for preventing aeration in the seaway.

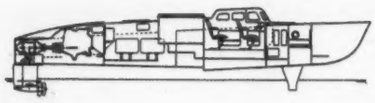


Stern foils, supporting struts, rudder and propeller shafts of the PT.50.

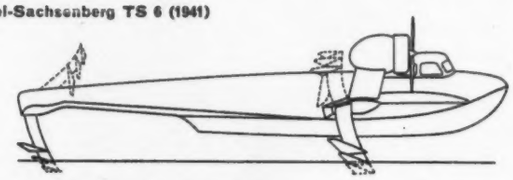




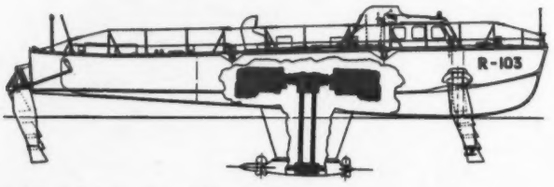
PT.90. General layout of Supramar's new long range vessel for 240 passengers. Maximum speed: 53 knots.



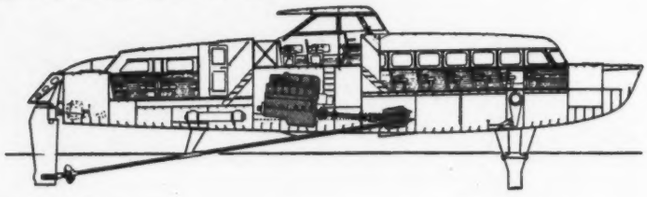
Schertel-Sachsenberg TS 6 (1941)



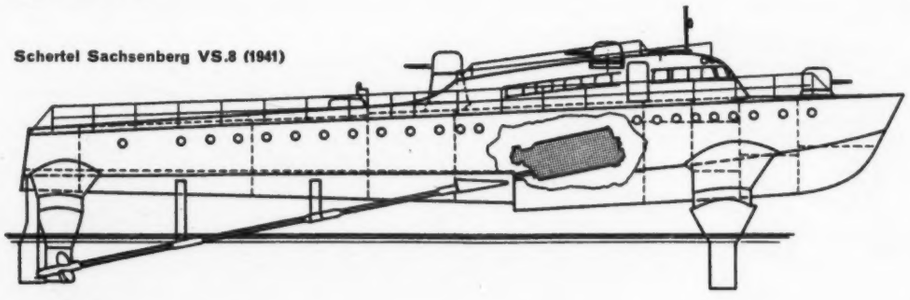
Dynamic Developments Inc. XCH-4 (1953)



Saunders-Roe Ltd. "Bras d'Or" (1957)



Supramar PT. 20



Schertel Sachsenberg VS.8 (1941)

These diagrams of some typical foil boats of the last 20 years, whilst confined to boats with surface-piercing foil systems, reveal marked differences in conception. This is specially true of the engines. The smallest vessel is the TS.6 (6.3 tons displacement) and the largest, the VS.8 (some 80 tons). The highest speed is achieved by the XCH-4 boat driven by aircraft engines and by propellers (2×630 h.p.). Whereas the boats shown here are without exception equipped with piston engines, the foil boat of the future should be predominantly gas-turbine driven.

change later on, should there be an increase in the demand for hydrofoil boats, especially for military purposes.

Orders for high speed "sea aircraft" as anti-submarine ships, landing craft, minelayers, torpedo boats, rocket boats and so on, could open up mass production possibilities for the aircraft industry, as happened at the time with the building of large flying boats.

To sum up, in the lower speed range the hydrofoil boat is inferior to all other types of vessels as regards power required. Its advantages do not emerge until speeds of over 30 knots, which is equivalent to three times the speed usual in coastal traffic. As long as the foil boat is used only as a short-haul vessel, it will hardly feel any competition from aircraft, and it is not easy to see where the line should be drawn. This is because, just as in the case of road and railway vehicles, the calculation depends on geographical and technical transport factors, which vary in each case.

Generally speaking, the commercial use of hydrofoil boats appears to be tied to a certain speed range, which at present lies between 30 and 60 knots. As regards military vessels, which are governed by different considerations, this limit will be extended, especially as the seagoing quality of hydrofoil boats is being constantly improved. The ranges, mentioned may of course change as a result of new physical knowledge and of further technical developments. A word of warning is however needed here, since it is all too easy to pass from prophecies of this kind into the realm of speculation of a more or less fantastic nature.

On the other hand, it is a fact that hydrofoil boats are already in service on many seas and around many coasts. Where they are once in service, it is hard to imagine doing without them. The future of modern shipping, it may be truly said, has now begun. ←→

The U.S. Navy's Hydrofoil Projects

*By Lieutenant Commander Perry W. Nelson, U. S. Navy**

Hydrofoil ships are now being successfully operated in many parts of the world. So far, their use has been mainly for commercial purposes on routes where speed is desirable, but recently the United States Navy has become keenly and actively interested in them as a result of modern developments in the submarine, which can now operate submerged for prolonged periods at remarkable speeds. Again, it is because of the desire for higher speeds in a surface ship, this time to combat a submarine threat, that the hydrofoil principle is being exploited.

Over the past twelve years, the United States Navy has been pursuing an active programme of investigation into the use of the hydrofoil principle for various Navy tasks. In this connection, theoretical studies as well as an extensive model and full scale test programme have been undertaken. These studies have covered practically all the arrays of foil configurations and arrangements, including surface piercing foils and fully submerged foils besides the various longitudinal area distributions of the foil, i.e. canard, tandem, or airplane type.

Sea Legs, the U.S.Navy's most successful test craft, which is illustrated overleaf, is 29 ft in length, 8 ft in beam and has a displacement of 11,000 lb. Powered by a 210 h.p. engine, the maximum speed attained by this craft is 31 knots. It utilizes a fully submerged foil system with a canard area distribution, and its most singularly successful feature is the autopilot system. Excellent seakeeping qualities have been demonstrated by *Sea Legs*, which has been run through four or five foot waves, both in following and head seas, with no loss in stability or control.

Based on the successful evaluation of this test craft, an operational military hydrofoil ship,

* The author wishes to make clear that the statements and views expressed in this article do not necessarily coincide with those of the Navy Department or Bureau of Ships.

designated PC(H), is being built for the U.S.Navy by Boeing. Its mission will be to carry out anti-submarine patrols in harbours, harbour approaches, and coastal waters, and it should give the U.S.Navy a small, relatively inexpensive surface ship capable of attacking high speed submarines. The ship under construction will be 110 ft in length and 31 feet in beam, with a displacement of 110 tons. Two propulsion systems will be provided, namely a diesel engine for hullborne operation, giving a cruising speed of 12 knots, and two gas turbines for foilborne operation, giving a speed of 40 to 50 knots. The foil system on the PC(H) is fully submerged and controlled by an autopilot system.

From the point of view of simplicity and economy, surface piercing foils would seem to be the logical choice. There are, however, two basic reasons why a submerged foil system was in fact selected. Firstly, with surface piercing foils, each change in the water surface is transmitted as a lift force to the hull because of the change in wetted foil area, which results in a rather rough ride as compared to the submerged foil system. Secondly, in a head sea the performance of a ship equipped with surface piercing foils is noticeably different from that in a following sea, this difference being a direct result of the orbital velocity of the water in the wave crest of a following sea. The two effects of this orbital velocity are to reduce the effective angle of attack and also the relative velocity of the water over the foil, and both effects tend to reduce the lift of the foil, at times to such a degree as to cause an accidental landing on the water. Such a performance characteristic would clearly be undesirable in an operational military craft.

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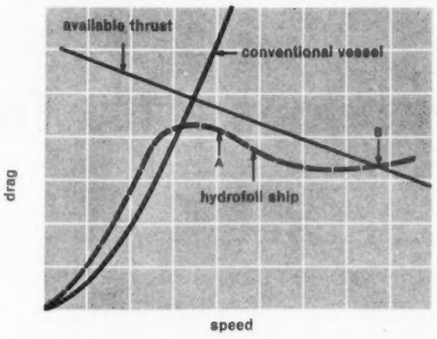
The hydrofoil ship as a means of transportation is now a reality, and in the near future the principle will be utilized in a military craft. How much larger and faster hydrofoil ships may be successfully built and operated depends upon the ability of the scientist and engineer to solve the many problems that stand in the way of further progress. Additional research and development are still necessary in the fields of hydromechanics, propulsion systems, structures and control.

The U.S. Navy's test craft *Sea Legs* (built by Gibbs and Cox Inc.) with her bow and stern foils fully submerged.



Comparison of the drag of a hydrofoil ship and of a conventional displacement vessel relative to speed. A is the phase at which the hydrofoil ship is becoming foilborne and B is its top speed.

To increase the speed of the hydrofoil, a new type of foil shape, known as supercavitating foil, will have to be used. Whereas, up to now, the results of the aircraft industry's careful testing and evaluation of airfoil section and wing configurations have, for the most part, been applicable to the design of the "wings" for subcavitating hydrofoils, in the case of supercavitating hydrofoils little is known about their behaviour, and consequently a whole new theory must be developed and tested. Early investigations have already shown that the problems to be overcome are manifold, as the examples in the following paragraph show.

First, tests have shown that the supercavitating craft have a lower lift/drag ratio. Furthermore, the foil operates just under the surface of the water, and there is a possibility that the cavity formed at the vapour pressure of water will be vented to the higher atmospheric pressure either through a strut or through the trailing vortex. Should this happen, the foil is no longer supercavitating but superventilating, and a considerable drop in lift will occur. Third, supercavitating foils are quite unlike subcavitating foils in that a major change in the angle of attack will give only moderate changes in lift. These then are three examples of the problems confronting the designers of high speed hydrofoil craft.

Another worry facing the designer of the larger, faster hydrofoil ship is to provide it with adequate power. Again, recourse has been had to the techniques in use in the aircraft industry where the necessary high performance engines, characterized by a low weight/h.p. ratio, a low specific fuel rate and high power output are to be found. Although the aircraft industry's gas turbines can be used, and do in fact meet most of the stipulations for hydrofoil ships, such engines must first of all be adapted for operation in a salt water environment. This involves the solution of problems of corrosion, life expectancy and reliability.

Once the designer has an engine which he feels will do the job, he must still find a way of converting the power to thrust, whether it be air screw, water screw or jet. If water screw is chosen, the problem then becomes one of providing a satisfactory, high performance drive.

Just as in the products of the aircraft industry, the weight going into the structure of the hydrofoil ship must be kept to a minimum, since each pound saved means an additional pound of payload. Since the hull of the ship represents a major portion of the weight, special care must be taken in its design; the production of a minimum weight high strength hull can be achieved only by combining the best of marine and aircraft technology.

The design and construction of the foils themselves must take account of the fact that the foils and struts must be relatively thin in order to reduce their resistance to a minimum and at the same time strong enough to support the full weight of the ship when in flight. In addition, they must be capable of withstanding the dynamic loads due to manoeuvring and heavy seas.

Resistance to elastic deformation, corrosion and erosion, as well as to fatigue, are essential yet difficult characteristics to provide.

The PC(H) class fast hydrofoil ship, developed by Boeing for the U.S. Navy, in flight. She has launched a high speed homing torpedo against an enemy submarine, which was detected by a sister ship using sonar equipment.

Finally, there is the question of proper autopilot control. The submerged foil system is not inherently stable in either heave or pitch and must therefore fly under constant supervision of the autopilot system, which accordingly must obviously be reliable at all times during take-off, in flight, and while landing. As speeds increase, the basic problems of control are intensified, since very high dynamic loads will prevent any over-control.

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From this brief discussion of hydrofoil craft, it can be seen that it has some very distinct advantages and shows promise of providing the long awaited high speed surface ship. On the other hand, it will be realized that there are many problems to solve before large high speed hydrofoil ships become a reality.

It is very encouraging to see that two great industries, aircraft and shipbuilding, with all their outstanding equipment and ingenuity, are making a joint effort to meet this challenge. ←

Bombers to Boats —

Boeing Develops a 100 Ton Submarine Killer

By Robert E. Bateman, Boeing Airplane Company

The engineering and production skills of the Boeing Airplane Company are now being applied to the U.S. Navy's newest class of ships—the hydrofoils.

Under a contract awarded last June, the company is producing a 110 ton, 115 foot hydrofoil craft for anti-submarine operations. This craft, designated the PC(H), will be the largest hydrofoil craft ever constructed and the first to be equipped with military weapons for this special Navy mission. In addition, an extensive research effort aimed at development of larger, faster military craft, has been underway for some time. These two projects have put Boeing firmly in the hydrofoil field. Incongruous as it may seem for an aircraft company to be interested in marine vehicles, the relationship is stronger than at first suspected. The design and construction of aircraft and hydrofoil craft pose similar problems of fluid dynamics, stability and control. The requirements for efficient, lightweight structures and propulsion systems are shared by both types of vehicle. This relationship of technologies is the force behind the entry of Boeing into the advanced marine field.

Much of subsonic aerodynamics is directly applicable to hydrofoils. Both the aerodynamicist and hydrodynamicist are interested in studying and determining pressures, velocities, forces, moments, flow angles and stable and unstable flow boundaries caused by fluids acting around various objects (hulls, foils, struts, nacelles, wings, etc.). For the hydrofoil boat, the hydrodynamicist has additional problems. Clearance difficulties, depth effects, wave-spray formations, cavitation and ventilation caused by operating near the water surface create decided differences in operation. The presence of surface waves poses an operating clearance problem for a hydrofoil craft. When fully submerged foils are utilized, the hydrofoil craft has a choice of contouring (following a wave at constant submergence) or platforming (clearing a wave by flying at constant pitch). The vertical accelerations encountered when contouring create limitations in this method of operation. A craft which must contour owing to surface piercing foil systems or short strut lengths is forced to reduce speed in high seas to avoid exceeding accelerations uncomfortable to the crew. The ability to platform and thus maintain high speed in a high sea-state is one of the principal reasons the submerged foil system is preferred for a military hydrofoil craft. Platforming, of course, requires sufficient strut length to maintain the hull above the highest wave expected to be encountered and still avoid foil broaching.

The presence of the free water surface also changes the local flow conditions about a foil. These changes can effect the force caracteristics of single foils and foils in tandem. A study of upwash and downwash effects shows that they follow the general patterns established by the aerodynamicist, but they are, however, complicated by the free water surface effects and the superposition of waves as illustrated in *figs. 1 & 2.*

The location of foils relative to one another must be carefully studied to minimize interference and drag.

As in aircraft design, the foil design and tailoring of foil characteristics is extremely complicated and has a critical influence on the ultimate performance of the vehicle. Besides the interference effects of upwash and downwash, additional interference effects are created by intersections of foils, struts, and nacelles. Aerodynamic experience dictates that fillet studies in the wind tunnel are required to minimize these effects in aircraft. Similar studies in water tunnels are required for hydrofoils.

One of the principal phenomena limiting the maximum force for a lifting surface in hydrodynamic flow is cavitation. Cavitation occurs whenever the local pressure is reduced to the vapor pressure of water. Besides creating high drag and loss of lift, the unstable flow condition can cause severe foil or propeller blade erosion. Much research and testing is still required to develop a full understanding of the phenomena of supercavitation, in which a relatively stable cavity is formed over the upper surface of a foil.

Although the general flow characteristics of the fluid mediums used by the aerodynamicist and hydrodynamicist are very similar, the higher density of water as compared to air permits a higher level of dynamic pressure of local loading acting on a given surface. High performance aircraft are designed for wing loadings of approximately 100 pounds per square foot. Hydrofoil boats on the other hand utilize foil loadings of at least 1,000 pounds per square foot. This factor of ten increases the structural problem and establishes the absolute necessity for maintaining smooth flow around any surface of the hydrofoil vehicle.

Maximum lift coefficients available to aircraft and hydrofoil designers, based on the present state of the art, are shown in *figure 3.* It should be noted that much of the hydrofoil research and testing to date has been concernes with solving basic problems. Until recently there has been comparatively little serious investigation of possible methods for increasing maximum lift coefficients. As the technology is refined, some improvement over that shown may be achieved.

Drawing of a 100 ton hydrofoil submarine destroyer designed by Boeing, under construction at the U.M. Martinac shipyards. Clearly visible are the port torpedo launcher, the air intakes of the two 3,000 h.p. gas turbines and a small weapon launcher behind the bridge.

The preceding discussion emphasized the need for both theoretical analysis and considerable testing in various types of hydrodynamic facilities. To provide a facility for obtaining hydrodynamic data, Boeing is building an experimental boat, termed a Hydrodynamic Test System. This system, designed to operate on quiet water areas of Lake Washington bordering Seattle, will provide a relatively inexpensive and quick method of obtaining preliminary solutions to hydrodynamic problems. The preliminary solutions will be checked at a later date in the more controlled conditions of a tow tank or water tunnel.

The Boeing hydrodynamic test system (HTS) is a hydroplane boat *(figs. 4 and 5)*, equipped with a jet engine (Allison J-33) capable of giving 4,600 pounds of thrust. The boat is 38 feet long, 17 feet wide, grosses over 10,000 pounds and is capable of sustained speeds of more than 100 knots. The vessel will be equipped with a supporting structure to hold and control various model foils and strut arrangements, and with instrumentation capable of obtaining continuous force, moment and pressure data. Facilities for underwater and above-water photography for the study of fluid flow conditions around the test foils will also be provided. Instrumentation and data analysis will include the effects of water surface variables such as wind, temperature, waves, etc. Boeing expects the HTS to provide reliable test data on hulls, foils or submerged shapes for all speeds up to 100 knots. Future preliminary work on supercavitating foil studies will be performed with this vehicle.

Hydrofoil craft. having fully submerged foil systems which exhibit little or no inherent longitudinal or roll stability, require an automatic control system basically similar to aircraft systems. The fully developed hydrofoil autopilot system must:

1. Control the craft during the transition from the hullborne mode to the flying mode or vice versa;

2. Maintain the hull clear of the water and prevent the foils from broaching during foilborne operation;

3. Provide for flat or coordinated banked turns as directed by the operator; and

4. Limit the severity of maneuvers to avoid exceeding the design dynamic loads and comfort limits of the passengers.

It may be noted that the control functions of 1 and 2 above are not normally required by current aircraft systems. Dynamic system analysis, the technology employed to accomplish these objectives, encompasses the intimately related special fields of hydrodynamics, structural dynamics and control dynamics. The complex nature of the dynamic stability and control problem generally requires the use of electronic analog computers to obtain solutions. These statements apply equally to airplane or to hydrofoil craft analysis. The factors involved and the functions to be considered are essentially the same. However, at least two significant degrees of difference are apparent when considering comparative dynamic performance requirements.

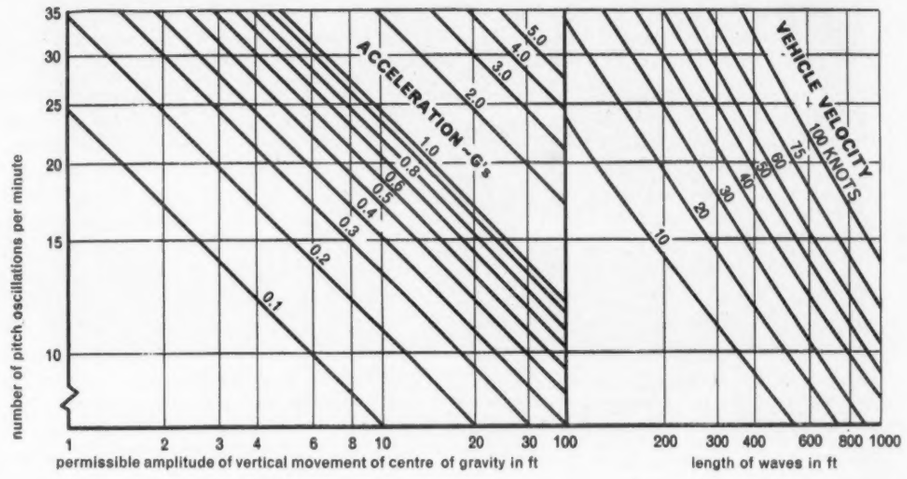

number of pitch oscillations per minute
ACCELERATION - G's
VEHICLE VELOCITY - 100 KNOTS
permissible amplitude of vertical movement of centre of gravity in ft
length of waves in ft

Fig. 1: Acceleration of the boat's centre of gravity as a function of own speed (set of lines on right), length and height of waves. It is assumed that the waves are sinusoidal in a head sea.

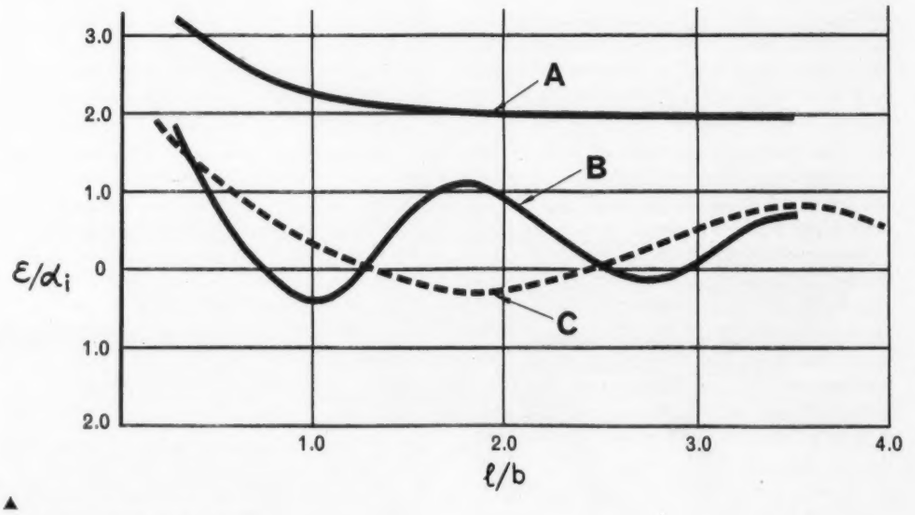


Fig. 2: Downwash comparison:
A – infinite medium; B – free surface medium ($V/\sqrt{g}$ low); C – free surface ($V/\sqrt{g}$ high).

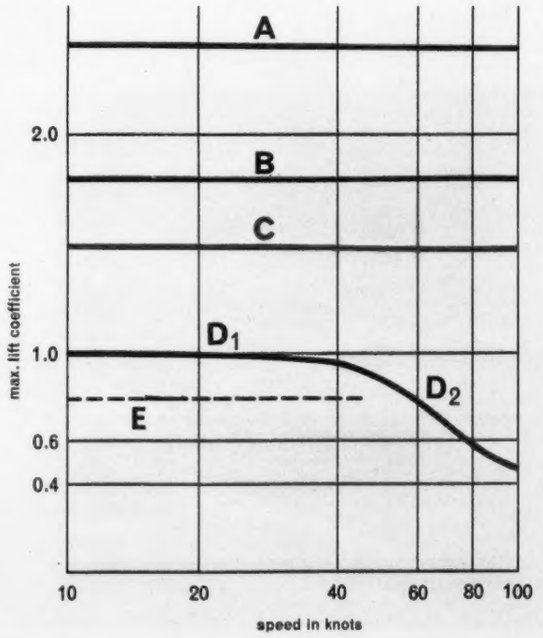


Fig. 3: Maximum lift coefficients at present obtainable with wings and hydrofoils.
A – aircraft with unswept wing, flaps down, gliding flight; B – aircraft with swept wing, flaps down; C – aircraft with swept wing, flaps retracted; D_1 – hydrofoil, flaps down; D_2 – supercavitating hydrofoil; E – subcavitating hydrofoil, no flaps.

First, hydrofoil craft are required to maintain a relatively precise altitude as a consequence of operation through the air-water interface. Height sensors based on either sonic or radar principles, which produce an electric signal proportional to the height of the craft above the water, have recently been developed. The autopilot accepts the generated electrical signal and modifies it as required, for use as a command to the control surface servos.

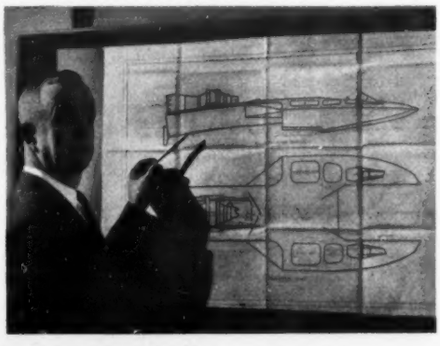
The second major difference is the nature of the disturbing forces which the hydrofoil craft may expect to encounter, as compared to an airplane. As a wave is encountered, the height sensor "sees" a relative change in the height of the boat above the water, and the foils each experience variations in the forces acting on them. The time relationship or phase lag between these disturbances is fairly obviously a function of the speed and direction of the wave relative to the craft, speed of the craft, and spacing of the foils. Solution of the resulting dynamic problem is complicated by nonlinearities in at least three places. The effectiveness of the foils as hydrodynamic lifting surfaces varies nonlinearly as a function of foil depth. The orbital velocity of the water particles in a wave vary exponentially with depth. The control surface actuators will probably exhibit nonlinear performance because of limits of their rate capability. Therefore, utilization of analog computers is the most practical approach to predict the dynamic response of the craft.

The successful development of hydrofoil craft will utilize technology already developed in the aircraft industry or adapted from it. Power plants are adaptations of aircraft gas turbines. Lightweight aluminum hull structures will utilize new methods of construction such as the use of integrally-stiffened extruded panels. Mechanisms such as those required for hydrofoil strut retraction and extension will incorporate many features in common with those of aircraft.

Nevertheless, while recognizing the applicability to hydrofoils of much aircraft technology, there are also many problems peculiar to these craft for which solutions must be sought in the traditions and experience of naval architecture and shipbuilding. Aircraft design experience must be augmented by marine architects and engineers, to achieve the marriage of thought and experience essential for successful hydrofoil craft design.

Basic technology applies equally to a commercial or military craft. Differences in the operation of a large military unit, however, entail design problems which differ from those of a commercial vessel. A commercial ocean-going craft would normally operate port-to-port on the foils. It must be able to fly in any sea normally encountered. It must also be able to survive if forced to land due to unusually high seas or mechanical failure. The military craft on the other hand must be designed to operate for extended periods on the open ocean. A large percentage of total operating time will be in the displaced condition. The crew must be able to continue effective operation and live without suffering undue hardships during long periods of high seas. Thus a major emphasis in the hull design must be placed on providing the best sea-keeping capability. In this respect a properly designed hydrofoil craft should have sea-keeping capabilities equal to a conventional ship of several times its weight.

Take-off in high sea-states, as required of a military hydrofoil craft, poses additional design problems. As design flying speeds increase, most efficient operation is obtained by increasing foil loading. Limits are imposed by the necessity for maintaining acceptable trim variations for control within cavitation boundaries in subcavitating designs and by structural considerations. Unfortunately, with hydrofoils as with airfoils, increasing foil loadings result in proportional increases in the take-off speed. Maximum acceptable take-off speeds are limited by considerations of power required, hull structure weight and other operational factors. Take-off speed for the military craft required to operate in high sea-states may be more severely restricted than for the commercial craft whose take-off would normally occur in relatively sheltered waters. Most high speed craft with supercavitating foils can be expected to utilize some form of auxiliary or variable area foils to achieve reasonable take-off speeds.



Figs. 4/5: Powered by an Allison J-33 turbojet delivering 4,600 lb thrust, this vessel is to serve as a floating test bed for submerged hydrofoils on Lake Washington from April onwards; it is designed for speeds of up to 100 knots. To keep test models in an undisturbed flow, they are suspended between the twin prows on a framework Boeing is using this boat to develop optimum hydrofoil configurations and layouts, as well as hull shapes for ocean-going hydrofoil ships.

Operation of military craft must also be compatible with the operation of other fleet units with which they will be deployed. In the normal hydrofoil craft there is a speed region in which operation is difficult and would ordinarily be utilized only while accelerating from displacement to flying mode and vice versa. This region lies between its design displacement speed and the speed for minimum drag while foilborne. Some missions may require that provisions be incorporated to permit reasonably efficient operation over much of this region while maintaining efficient high speed capabilities. Various design techniques can be applied to achieve an increased range of speed capabilities and thus reduce, or virtually eliminate, the region of limited operation. However, the requirement to do so could impose serious design compromises on the military craft not shared by commercial design.

Development of military equipment specifically adapted to hydrofoil craft is of paramount importance in achieving ultimate operational capability. The manner in which these developments are guided and the results achieved should and will greatly influence the future design of hydrofoil craft. Sonar development is most certainly of the utmost importance to successful adaptation of hydrofoil craft to anti-submarine warfare. The affects of noise generation, transmission and radiation on the craft's own sonar and on other units in the area are largely unknown and require detailed investigation. The integration of the basic craft and its subsystems into an effective operational unit is a task in which the aircraft industry has had much experience. Military aircraft and missiles have required a complete integration of the elements of the system. While the physical items may be different, the disciplines developed are directly applicable to the design of hydrofoil craft where complete integration of the system is as important to success as in aircraft.

The hydrofoil craft promises to provide the surface fleet with the high performance combined with staying power required to combat the tremendously improved speed capabilities of the modern nuclear submarine. The basic technology and design tools are available.

The extensive directly applicable technical experience existing in the aircraft industry places it in a logical position to lead the way to development of larger, faster hydrofoil craft optimized for military missions. ←→

Grumman Hydrofoil Boats

The Dynamic Developments Inc. XCH-4 experimental hydrofoil craft, powered by two 630 h.p. aircraft engines with propellers. The boat, which weighs roughly eight tons, has three pairs of foils on each side of its hull, arranged vertically one above the other. The stern is also supported by a system of foils arranged vertically. The supports of the port and starboard wings are fitted on fin-like booms on the fore boat hull and can be swivelled backwards and upwards when the boat is in calm seas to reduce draught to roughly three feet. At higher speeds, the top pair of foils lifts right out of the water, as shown in the picture. The 50 ft boat reaches a maximum speed of 75 knots.

Among the firms in the American aircraft industry which have recently been showing increasing interest in the construction of hydrofoil boats is Grumman Aircraft Engineering Corp., Bethpage, N. Y. As early as 1956 Grumman acquired a 50% holding in Dynamic Developments Inc., Babylon, N. Y., a firm specializing in the development of hydrofoil boats. By combining the production capacity of its facilities and their experience in flying boat manufacture with the development potential of the engineering firm, Grumman Aircraft is now in a position to accept substantial Navy orders for fast hydrofoil craft, thus obtaining a footing in a sector whose significance is expected to increase considerably in coming years.

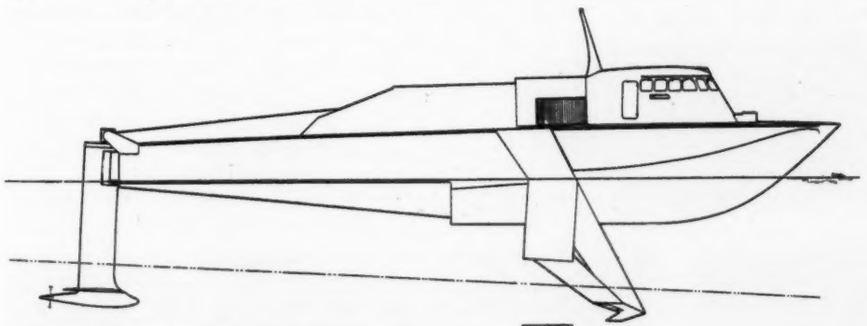
Over a year ago Dynamic Developments Inc. received a $1.5 million contract from the Maritime Administration of the U.S. Department of Commerce to build a fast experimental vessel to investigate the behaviour of hydrofoil craft travelling at high speeds in heavy seas. The Maritime Administration decided on an 80 ton boat for speeds of 60 to 80 knots which, powered by a converted Pratt & Whitney J57 gas turbine, could transport a load of nearly 30 tons (fuel and payload). The boat, which is built entirely of aluminium alloy, is scheduled to leave the stocks in June 1961 and will then be subjected to rigorous speed and seaworthiness tests. The three-view drawing below is the first to show details of the new hydrofoil system chosen. In addition, Dynamic Developments received a contract some years ago from the Office of Naval Research to develop a boat with super-cavitation foils, powered by a General Electric gas turbine.

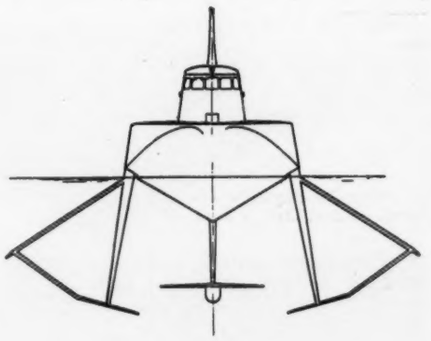
So far, Dynamic Developments Inc. has been granted 17 patents for underwater hydrofoils; all concern the improvement of stability and the ability to maintain adequate take-off speed in heavy seas. That these patents have more than a mere paper value has been demonstrated beyond all doubt. An experimental craft, XCH-4, built by Dynamic Developments for the Office of Naval Research and powered by two 630 h.p. aircraft engines with propellers, has reached speeds of up to 75 knots during trial runs. The attainment of speeds of this order appears to indicate that the development of super-cavitation foils in recent years has made more rapid progress than originally anticipated.

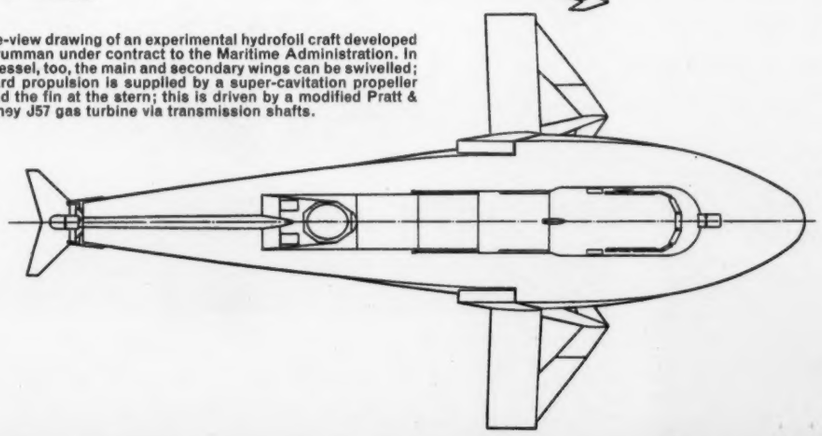
In principle, the Dynamic Developments hydrofoil systems have a main foil unit slightly to the fore of the centre of gravity, fitted so that the swept foils cut through the water just below the surface; in addition, there is a small stabilization fin at the stern. This arrangement not only enables a high degree of stability to be achieved, with rapid damping in heavy seas, but also promises excellent manoeuvrability at high speeds.

It will be interesting to see the results of the first trial runs of the 80 ton boat, whose W-shaped foil will undoubtedly enable it to reach high speeds—though it is likely that a number of modifications will have to be made to the design, in view of the impressive dimensions. ←

Model of a combat vessel projected by Grumman. The foils, which are of a new design, can be swivelled backwards and upwards, together with the stabilization fin under the stern, for slow speeds in calm seas. The main foil system has a vertical support strut on each side and a cranked V-wing with swept tips.





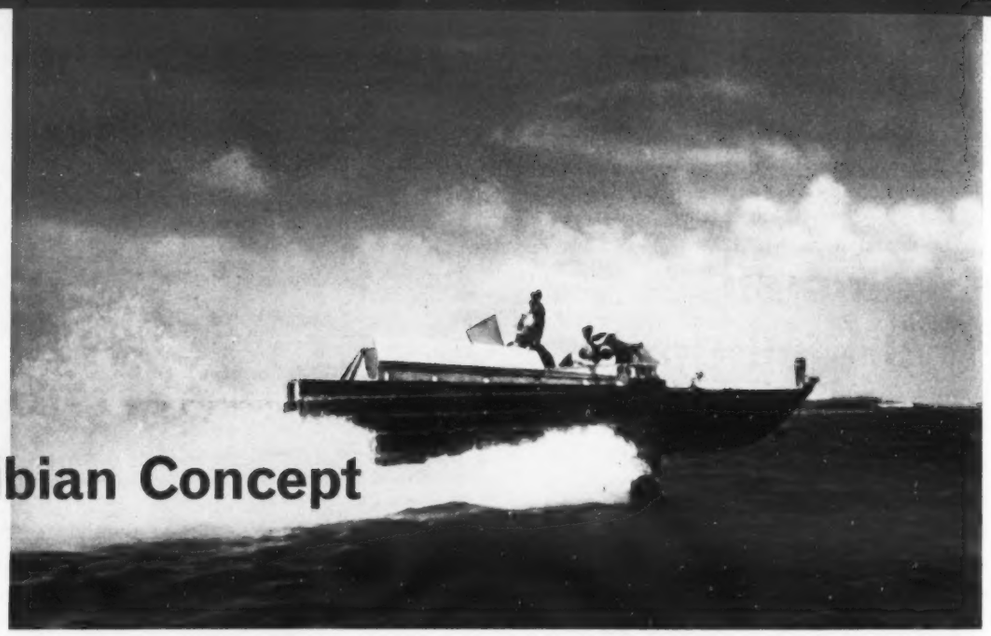


Three-view drawing of an experimental hydrofoil craft developed by Grumman under contract to the Maritime Administration. In this vessel, too, the main and secondary wings can be swivelled; forward propulsion is supplied by a super-cavitation propeller behind the fin at the stern; this is driven by a modified Pratt & Whitney J57 gas turbine via transmission shafts.

Overall length	104 ft 0 in.
Water line length	95 ft 10 in.
Beam	21 ft 6 in.
Draught (with foils down)	19 ft 9 in.
Draught (with foils up)	6 ft 6 in.
Design speed	over 60 knots
Standard displacement	80 tons
Load (payload and fuel)	29 tons
Radius of action (foilborne, with 10 tons payload and 10% fuel reserves)	655 n.m.

Lycoming Offers

The Hydrophibian Concept



The *Flying Duck*, an experimental vehicle equipped with hydrofoils, developed by Lycoming from a DUKW amphibious landing craft under contract to the U.S. Army Ordnance Corps.

Fast Turbine-Powered Landing Craft*

The problem of landing from the sea on an enemy coast and providing logistic support for the building of bridgeheads is as old as military history. Admittedly, it has never been easy to achieve surprise and a speedy build-up of forces, but the dispersal required in these days of nuclear weapons demands a high degree of mobility and efficiency.

Although the military need is important, there is nevertheless an upper limit to the cost of amphibious equipment. The problem can be stated as the development of simple, rugged vehicles of greatly improved speed and logistics efficiency. Until recently, the problem had been handled by conventional "swimming" vehicles aided by helicopter airlift and backed by large beaching landing craft. The service provided by the helicopter is adequate in mobility and vital in bypassing natural obstacles, but is costly in terms of cargo delivered per horsepower and equipment. On the other hand, large amphibious vehicles are too slow. Their water speed is limited to less than ten knots, and their radius of action in half an hour's assault time is extremely small. Judged by the speed of today's retaliation, they are virtually static in the water once they are committed and must thus be released at high hazard very close inshore.

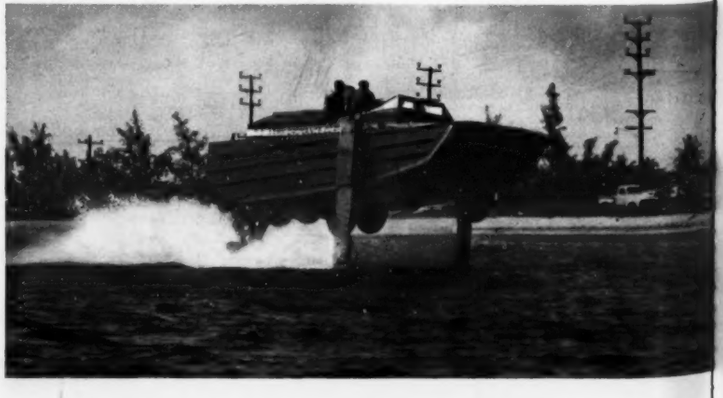
Three developments are now in being that promise to modernize amphibious tactics to a point adequate to cope with today's realities: the development of hydrofoils, the progress made with ground effects machines, and the availability of rugged gas turbines with low specific fuel consumption.

Each vehicle is subject to natural laws that determine speed produced for a given specific power. Above this given speed, whose range is normally very limited, the vehicle becomes uneconomic and must be superseded by another more appropriate type. Here amphibious vehicles are in a difficult position: not only must they have as wide as possible a speed range, but they must also be as efficient on land as on water. When operating on water, amphibious vehicles are comparable to conventional displacement vessels and are subject to the same laws; a further increase in speed is thus limited by the rapidly increasing wave drag. In the case of a small amphibious craft, for instance, the installed power of about 17 h.p./ton must be doubled to increase the water speed from 10 to 12 knots. If the craft is designed to come out of the water and plane along the surface, speeds of about 40

* The article which follows is based on a paper read by Kenneth A. Austin and Louis S. Votre of the Avco Corporation Lycoming Division at a meeting of the Chicago Section of the Society of Automotive Engineers in October, 1960 ("Turbine Driven Amphibians—The New Trend in Fast Assault Craft").

The *Flying Duck* hydrofoil amphibian during a trial run. As the craft reaches take-off speed, the bows first rise out of the water, and then...

...the entire vehicle, supported solely by its submerged hydrofoils, travels across the water three feet above its surface.



knots can be obtained at a power of some 100 h.p./ton. The hard ride of such a craft in choppy weather, however, frequently prevents the attainment of design speeds, and in heavy seas operations may become impossible. What is more, an installed power of 100 h.p./ton is highly uneconomic, for an amphibious vehicle must also operate on land, where the power requirement is seldom more than 15 h.p./ton.

From the foregoing, it can be seen that a mere increase in the specific power of conventional designs will not enable an amphibious vehicle to meet the speed, seaworthiness and economy requirements for a fast landing craft of tomorrow. Designers must therefore aim not at increasing the installed power per weight, but at improving speed and seaworthiness for the same power and weight.

In an endeavour to improve the performance of amphibious landing craft, Lycoming has been investigating the possibility of retracting the wheels during water operations to reduce drag on the hull. Although wheel retraction and hull streamlining have reduced drag by 25% at speeds of around 8 knots, even this has not enabled the desired three- to fourfold speed increase to be achieved.

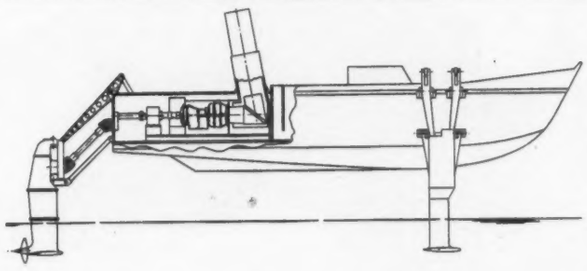
*

Only the hydrofoil has shown any promise of success, and Lycoming has therefore investigated various hydrofoil configurations. For a small amphibious craft, the power requirement for 40 knots is about 50 h.p./ton, increasing to 100 h.p./ton for 55 knots. This shows a speed increase of 37% over the planing hull for the same specific power, and results in a smooth shock-free ride with excellent manoeuvrability clear of all waves. Above 65 knots, where cavitation becomes a predominant factor, power requirements rise steeply, and for a 20 ton boat would be up to 180 h.p./ton at 70 knots. Speeds below 65 knots should, however, be adequate for amphibious operations, as they represent a considerable improvement over the 7 to 10 knots obtained with conventional amphibians during the last war.

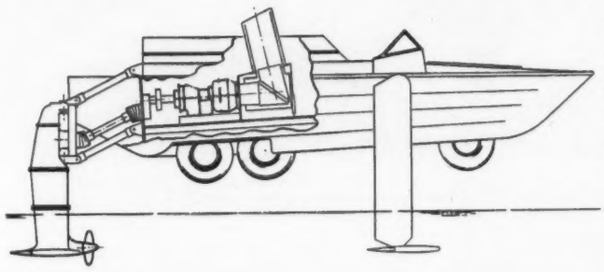
A critical part of any amphibious landing is passage through the surf and emergence from the sea as a land vehicle, and until recently only the helicopter could travel from sea to shore without endangering troops and logistic supplies. In the last two years, however, development work has shown that ground effects machines of sufficient size and propulsive power can accomplish this manoeuvre with ease. These demand a lower specific power than helicopters of the same transport capacity, and although their power requirements are higher than those of hydrofoil boats, they can travel at higher speeds.

Even today, however, it is clear that the hydrofoil amphibian will take the place of the conventional landing craft, and that the ground effects machine will oust the helicopter. Each of these vehicles could be assigned specific tasks which they could fulfil with high efficiency. The purpose of the present article is primarily to discuss the significance of the hydrofoil for amphibious landing craft and indicate the powerplants which give the hydrofoil amphibian its high overwater speed.

Theoretical research has shown that, despite its relatively high specific fuel consumption, the gas turbine is superior in performance for short missions to the supercharged diesel engine, which becomes advantageous only for missions of 20 hours or longer. For the designer is interested not only in fuel weight, but in the overall weight of the engine installation, including fuel, necessary to obtain a given range. And in this respect the ultralight gas turbine (with an SFC of 0.6 to 0.7 lb/h.p./h) is more favourable than the considerably heavier diesel engine of the same power. For instance, a turbine-powered hydrofoil amphibian designed for a five-hour mission (specific weight 1.0 lb/h.p.) can carry



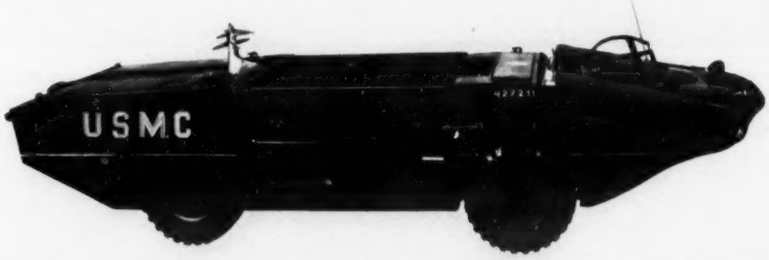
The 15 ton *Halobetes*, built by the Miami Shipbuilding Corporation, was one of the most important experimental craft in the U.S. Navy's hydrofoil programme. The sectioned drawing shows the position of the Lycoming T53-L-1 gas turbine and the cranked shaft which drives the propeller on the aft hydrofoil.

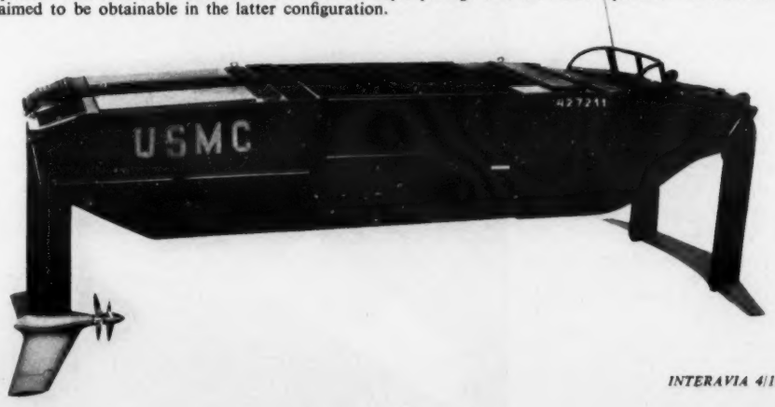


Sectioned drawing of the amphibious landing craft converted by Lycoming and the Miami Shipbuilding Corporation and tested for many years under the name *Flying Duck*. Fitted with a Lycoming T53 gas turbine and submerged hydrofoils, it can reach speeds of over 30 knots. The turbine and propeller shaft layout are similar to those of the *Halobetes*.

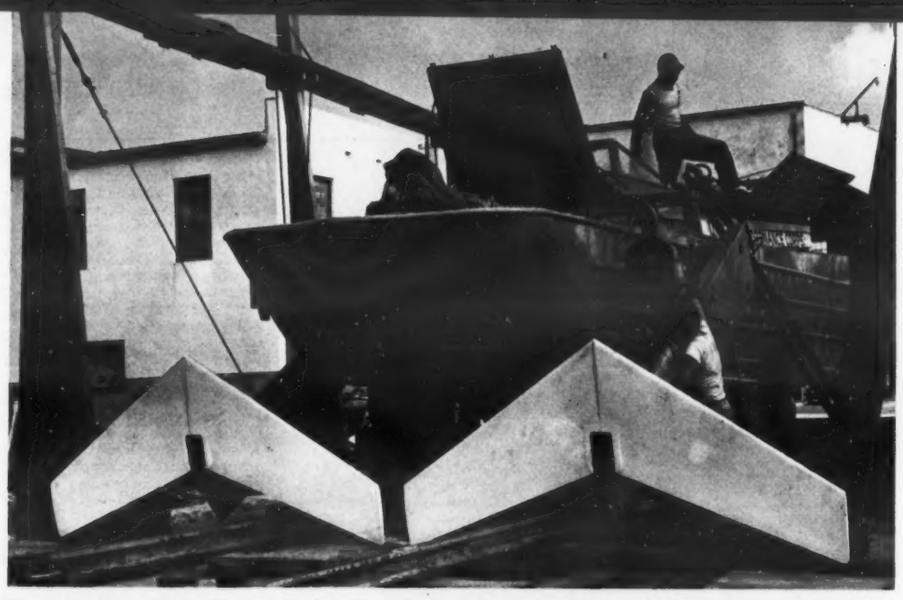
Technical data for the Flying Duck experimental amphibian

Span of the two forward hydrofoils	9 ft each	Cruising speed	30 knots approx.
Span of rear foil	12 ft	Take-off power requirement	600 h.p.
Load distribution on hydrofoils	⅔ forward, ⅓ aft	Permissible wave height at full speed	4 ft approx.
Maximum weight	29,600 lb	Propeller speed at full speed	1,800 r.p.m.
Take-off speed	13 knots		



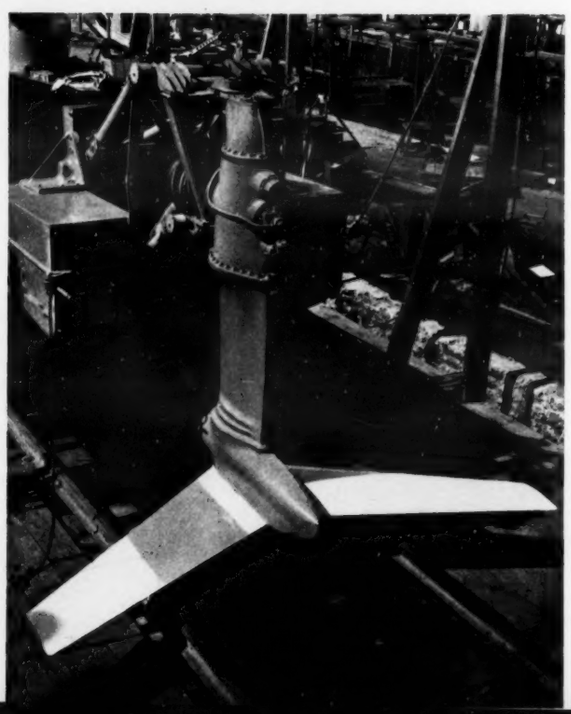


This amphibious craft designed by Lycoming and fitted with a Lycoming gas turbine and variable incidence hydrofoils is known as the *Hydrophibian*. Upper picture shows the vehicle with foils retracted ready for beaching, lower picture the *Hydrophibian* with foils down and wheels retracted for rapid passage over the water. Speeds of the order of 40 knots are claimed to be obtainable in the latter configuration.



The two forward submerged hydrofoils of the *Flying Duck* experimental craft are mounted on swivelling struts by means of a hinge pin, enabling the angle of incidence of the foils to be controlled either manually or by an automatic pilot. Each foil weighs 600 lb.

Two large hatches on top of the vehicle give easy access to the Lycoming gas turbine of the *Flying Duck*. The powerplant is a standard 880 s.h.p. T53 helicopter turbine.



The rear strut is approximately 10 ft long and swivels about a horizontal axis. It also carries the driveshaft of the submerged propeller.

a larger payload than an equally powerful piston-engine craft. Moreover, a turbine takes up less room than a piston engine, and because of its lower weight and space requirement can be installed at any point in the vessel. Finally, the use of the free turbine configuration offers the additional advantage of high torque at low propeller speed, giving a good take-off thrust and excellent acceleration. As demonstrated in the U.S. Navy *Halobetes* programme, the take-off distance for the turbine-driven hydrofoil was less than half that required for the same craft with piston engine propulsion. Moreover, the low vibration and noise levels and the possibility of using a variety of fuels are extremely important.

*

Installing an engine in an amphibious vehicle poses a number of difficult problems.

1 – Sea spray and waves

Every vessel that swims slowly through the surf is subject to critical damage from breaking waves. These are particularly dangerous when running into the beach, as the difference in speed between the vessel and the wave front is small, and the wave may sweep the craft from end to end. It has been found that the crew compartment in the bows or immediately behind is the point least affected, and air ducting should preferably be in this position.

Although the heaviest spray particles can easily be separated from the air, the engine must nevertheless be capable of accepting a high concentration of water droplets and be proof against sea water corrosion.

2 – Cooling

For all these high-speed vessels, engines can no longer be cooled by sea water. Fortunately, the gas turbine is a natural air-cooled engine, and its secondary oil cooling requirements are small. The oil cooling package should preferably be integrated with the engine. Cooling air for the engine compartment can be circulated through and led out via the exhaust system.

3 – Sand and dust

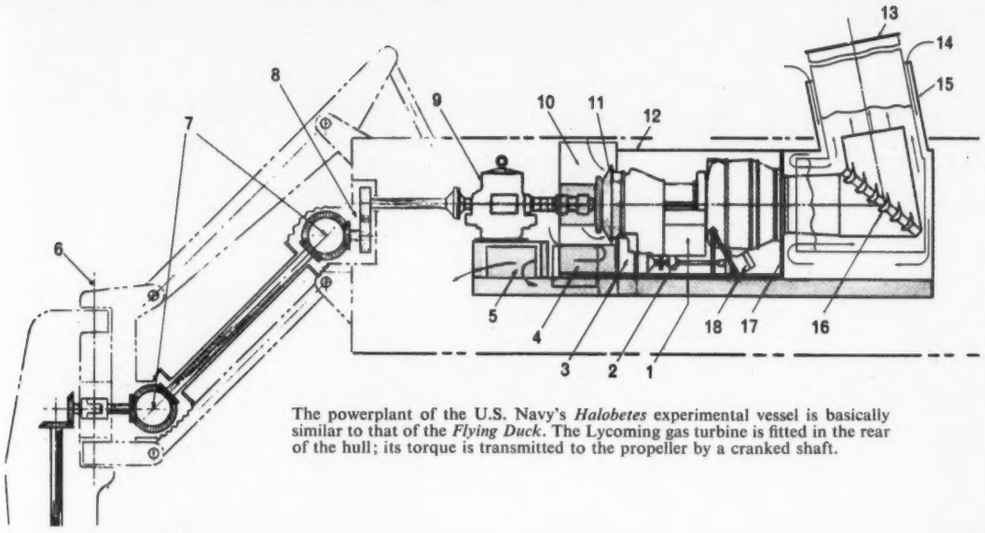
Land operation on unprepared surfaces generates plenty of sand and dust. Engine blading and oil systems must be capable of extended operation under these conditions. Here experience shows that particle sizes of up to 80 microns are acceptable to a robustly constructed turbine.

4 – Auxiliary power

Auxiliary power in hydraulic and electrical form is required at up to 10% of installed propulsion power. At least half of these services must be available when the vehicle is standing still.

5 – Maintenance

Amphibious assault operations are demanding and usually take place in tough terrain; engines must hence be exceptionally rugged and self-sufficient. Self-caring systems should be used wherever possible, as maintenance will be strictly limited, or postponed completely, during actual landings.



1 – Lycoming gas turbine Model LTCIB-1 (T53-L-1)
2 – Power take-off
3 – Turbine oil tank
4 – Oil cooler fan
5 – Oil coolers (turbine and reverse gear)
6 – Steering axis
7 – Variable angle bevel gear transmission units
8 – Transom gearbox
9 – Reverse and reduction gearbox
10 – Air intake duct
11 – Inlet screen and water spray ring
12 – Turbine compartment cowling
13 – Exhaust stack inner casing
14 – Induced airflow
15 – Exhaust stack outer casing
16 – Exhaust corner bend assembly
17 – Fireproof bulkhead
18 – Hydraulic pump

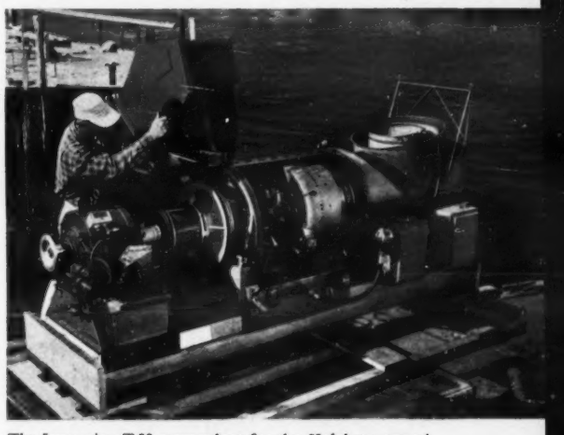
The powerplant of the U.S. Navy's *Halobetes* experimental vessel is basically similar to that of the *Flying Duck*. The Lycoming gas turbine is fitted in the rear of the hull; its torque is transmitted to the propeller by a cranked shaft.

Studies and practical experiments carried out by Avco Corporation have demonstrated the feasibility of an amphibious craft with retractable hydrofoils and gas turbine powerplant. On receipt of a U.S. Army contract, the Lycoming Division and its sub-contractor, the Miami Shipbuilding Corporation, proceeded to convert a World War II DUKW amphibian which made its first test off the Florida coast in July, 1959 under the designation *Flying Duck*.

The modifications to the standard amphibian included the reinforcement of the bow and chassis, the installation of a Lycoming T-53 marine power package, over-the-stern drive and aft hydrofoil assembly, forward struts and controllable submerged hydrofoil assemblies, hydropilot to guide the vehicle over the water, and associated equipment. Although submerged hydrofoils are considerably more complicated than the surface-piercing V configuration, as they require automatic controls to keep the foil at a constant depth and prevent the boat from pitching, they were nevertheless selected as they are superior in rough water (particularly in following and beam seas), permit tighter turns and will support approximately three times the load per unit of area.

For the roll and pitch control and stabilization of the *Flying Duck*, the two forward hydrofoils are swivel-mounted at the trailing edges on two vertical struts, their angles of incidence being altered to provide pitch and roll stabilization. After acceleration to a speed of about 13 knots, the hull lifts out of the water, and in normal high-speed operations only the two forward hydrofoils and the aft foil penetrate 30 inches into the water. At a speed of some 30 knots, the *Flying Duck* can operate for five hours without refuelling and cover distances of the order of 150 nautical miles.

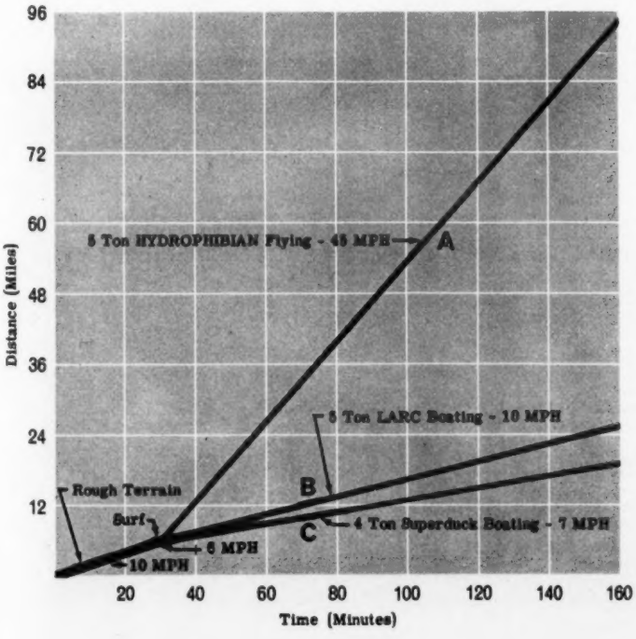
When the U.S. Army Ordnance Corps gave Avco Corporation the contract to convert the DUKW into a hydrofoil amphibian, it had two main aims: to prove that an amphibious vehicle could be fitted with submerged hydrofoils and powered by a gas turbine; and to develop a highly mobile multi-purpose vehicle for speedy transport of troops and logistic supplies over long distances, even in heavy seas. Here it was assumed that the hydrofoil amphibian to be developed would have to operate from coast to coast and from an ocean-going mother ship to the coast and that it could, if necessary, be equipped with a variety of weapons for special missions.



The Lycoming T53 powerplant for the *Halobetes* experimental craft.

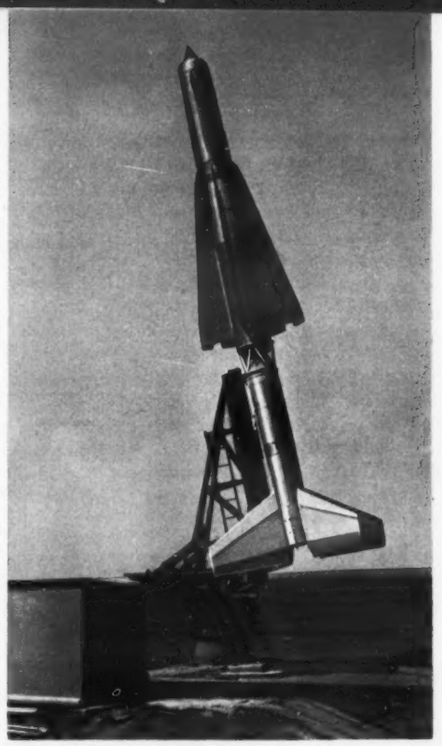
The new high water speed wheeled amphibian designed by Lycoming is a 5 ton gas turbine-powered vehicle known as the *Hydrophibian*. It is capable of land speeds up to 55 m.p.h., negotiating a 60% grade, travels at up to 45 m.p.h. over water, can go through surf as well as the World War II DUKW and has retractable wheels and marine drives. Its cargo space is 400 cu.ft., and it can recover from a 45° list while carrying a 10,500 lb Conex container. Its hull is of stressed aluminium skin. Its curb weight is 20,000 lb, and its gross weight is 30,000 lb. Controls are simplified to two speed ratios forward, and one reverse for land operation. When the vessel is flying, the hydropilot adjusts the foil for take-off and maintains flight altitude; the driver can take off or land simply by advancing or retarding the throttle and maintaining directional control.

Today, now that the *Flying Duck* craft has been successfully tested, the U.S. Army, the Marine Corps, the Navy, the Coast Guard and even the Air Force are showing interest in the *Hydrophibian* concept. Not only as a fast troop and supply transport, but also as a mobile guided missile platform, frog-man transport, patrol and air-sea rescue vessel, the *Hydrophibian* will play a vital role in future operations at sea. ⟷



The distance (in miles) per unit of time (minutes) covered by the landing craft determines the transport capacity. The *Hydrophibian* (A) can carry a payload of five short tons over a distance of 95 miles in 160 minutes, while the LARC amphibian (B), designed for the same payload, can cover only 25 miles at normal cruising speed, and an amphibian of the *Superduck* type (C) as little as 20 miles. When travelling over rough terrain and through surf, all amphibious vehicles must lower their speed; here it is assumed that they must all travel 4 miles over rough terrain at a speed of 10 m.p.h. In addition, it is assumed that they will be crossing a zone of surf half a mile wide at a speed of 6 m.p.h.

Rockets, Missiles and Space Vehicles



Nord-Aviation *Vega* experimental ramjet-powered vehicle

Lunar Research with Surveyor

Three vehicles are at present on the NASA lunar research programme: *Ranger* (cf. *Interavia* No. 1/1961, page 98), *Surveyor* and *Prospector*. The Jet Propulsion Laboratory of the California Institute of Technology is entrusted with carrying out the *Surveyor* programme. Walker E. Giberson, JPL *Surveyor* Project Manager, says that research programmes with vehicles of the *Surveyor* type have been shown to be feasible by a number of studies. In May, 1960, JPL sent specifications to a number of American firms, and in July study contracts were awarded to Hughes, McDonnell, North American and Space Technology Laboratories. After examination of the four studies, NASA began negotiations with Hughes in mid-January this year for the construction of seven space vehicles, to be launched from Cape Canaveral by *Atlas-Centaur* booster; total cost of the *Surveyor* programme is estimated at over $50 million.

At the first public showing of a *Surveyor* mockup (see picture), engineers of the Jet Propulsion Laboratory and Hughes Aircraft Company gave details of the project. The vehicle itself will weigh some 2,500 lb as it enters a lunar orbit and 750 lb after it makes its soft landing on the moon at a speed of 6 m.p.h. The scientific and technical equipment will weigh about 200 lb.

The following information has been released on the tasks and equipment of the *Surveyor* craft. Chemical analysis of the moon's surface: X-ray spectrometer, neutron activator, mass spectrometer and equipment for gas chromatography (detection of organic molecules). Physical analysis of the moon's surface: densitometers, equipment for measuring electrical and thermal conductivity, the speed of sound, and four television cameras with lenses of variable focal lengths.

A drill will penetrate the moon's surface to a depth of 60 inches and collect samples of the moon's crust for analysis in the vehicle. For subsurface analyses the *Surveyor* will carry an X-ray spectrometer, neutron activator, a densitometer and equipment for measuring the vertical temperature gradient, electrical and thermal conductivity. A three-axis seismometer and a gravimeter will also be used for investigations of the lunar structure.

The first *Surveyor* launchings are scheduled for 1963. The trip to the moon will take 66 hours; NASA's Deep Space Instrumentation Facility will be responsible for tracking and guidance. With the aid of small gas reaction jets and optical sensors, the *Surveyor* will be stabilized so that its antennas are directed earthwards and its solar cells turned towards the sun; its impact on the moon will be softened by a retro rocket and two control rockets.

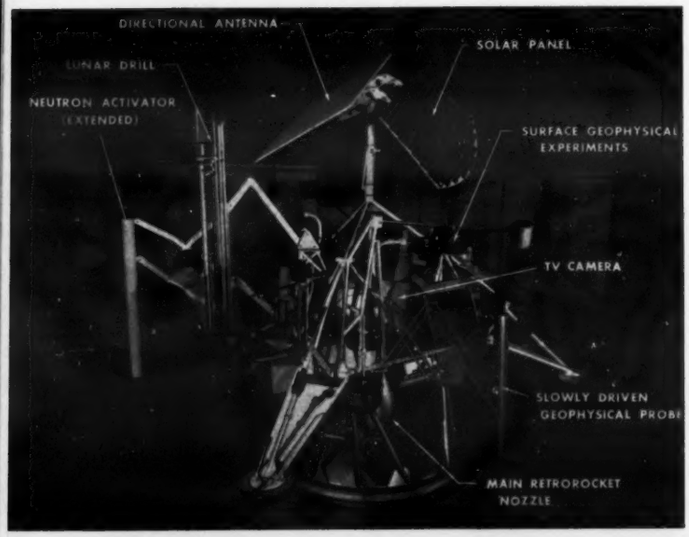
The television equipment consists of four fixed-position cameras, three pointing up and one down. Above each of the upward-pointing cameras is a gimbal-mounted mirror enabling them to take photographs through 360° of azimuth and 15° above to 45° below the horizontal line of the spacecraft.

Project Mercury Progress

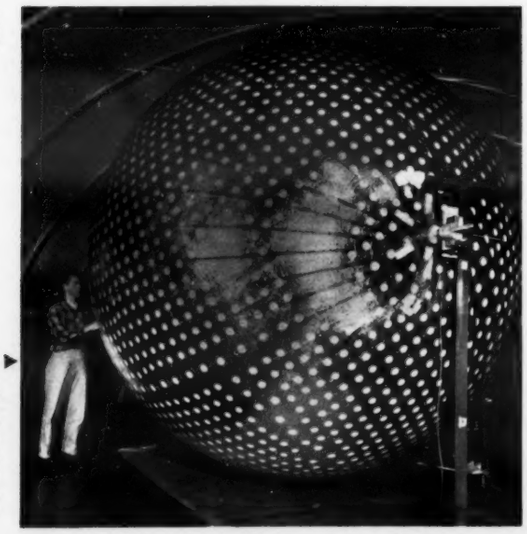
Following the success of the *Mercury* MR-2 experiment (*Redstone* booster) with a chimpanzee in the rocket recovery capsule, an unmanned capsule was launched by *Atlas* booster from Cape Canaveral on February 21st. This was the space capsule's toughest test since the beginning of the manned space flight programme. Carrying a 200 lb instrument payload, the capsule reached a peak height of 107 miles on its ballistic trajectory; its maximum speed during re-entry was 12,780 m.p.h. It impacted in the Atlantic 1,430 miles from Cape Canaveral, north-east of Puerto Rico, and was recovered 43 minutes after launching. The seven *Mercury* astronauts were present at the launching; three of them—Lieut. Colonel John H. Glenn, Jr., of the U.S. Marine Corps, Captain Virgil L. Grissom of the U.S. Air Force, and Commander Alan B. Shepard of the U.S. Navy—have been short-listed for the first manned *Mercury* experiment.

Vega Experimental Vehicle

Nord-Aviation has begun flight testing the new ramjet-powered *Vega* experimental vehicle. The following data have been published: length 19.4 ft; span 6.2 ft; maximum fuselage diameter 2.1 ft; launch weight 1,430 lb; useful volume in nose 8,540 cu.in.; useful volume in tail section 4,270 cu.in.; payload up to 660 lb depending on programme; speed Mach 4 to 5; ceiling 65,000 to 115,000 ft; range with 26.4 Imp.gal. of fuel about 160 n.m. ←→



◀ Full-size mockup of the *Surveyor* space vehicle, showing the layout of the vehicle components.



Explorer 9 balloon satellite for air density measurements, which has been in orbit since February 16th. In the picture, dots of reflecting paint are being applied to the satellite; these cover 17% of its surface and prevent overheating and over-expansion of the balloon when exposed to solar radiation. ▶

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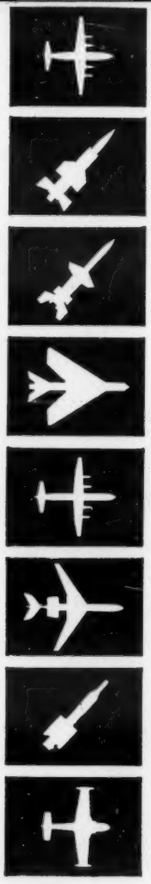

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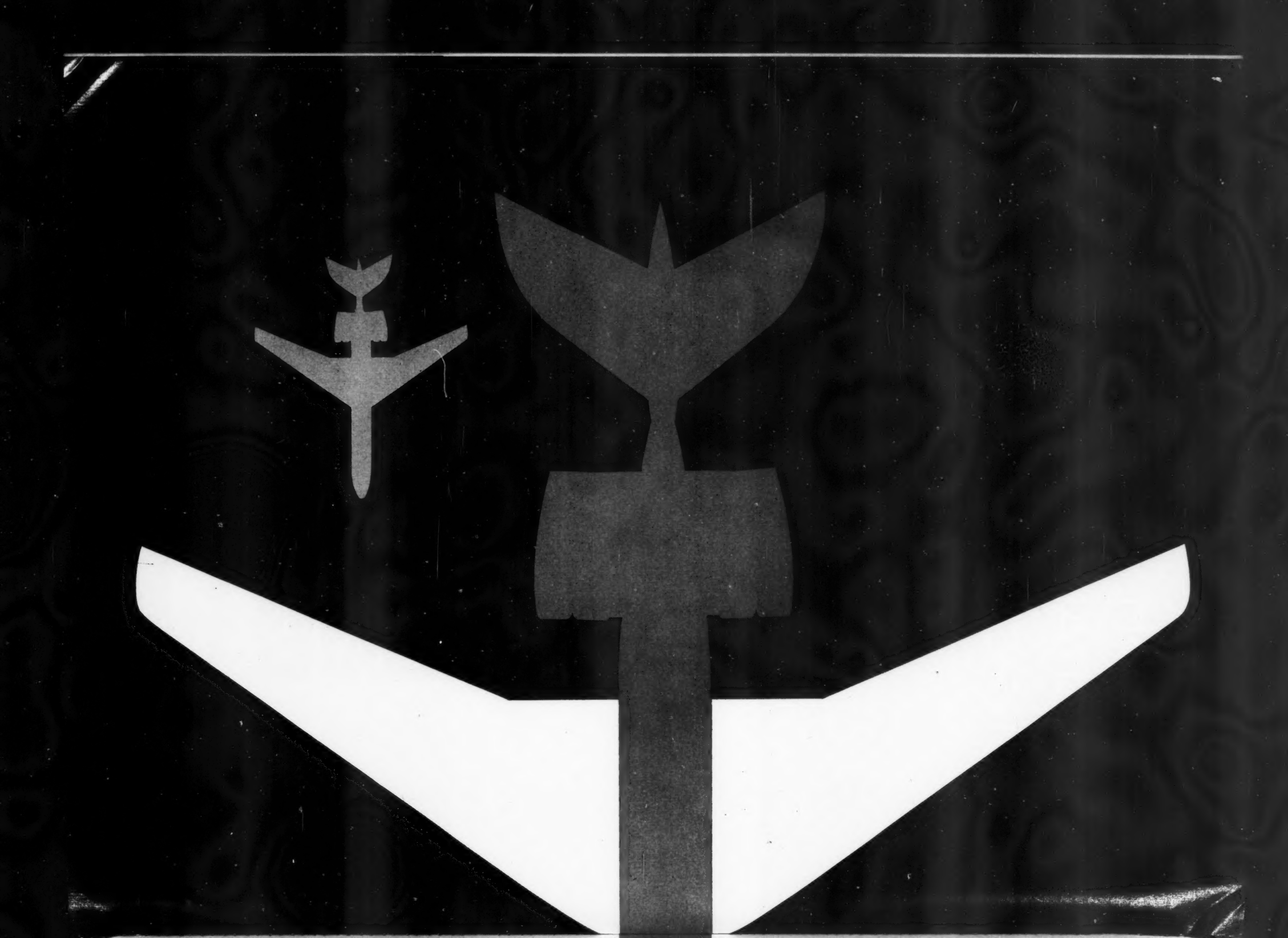

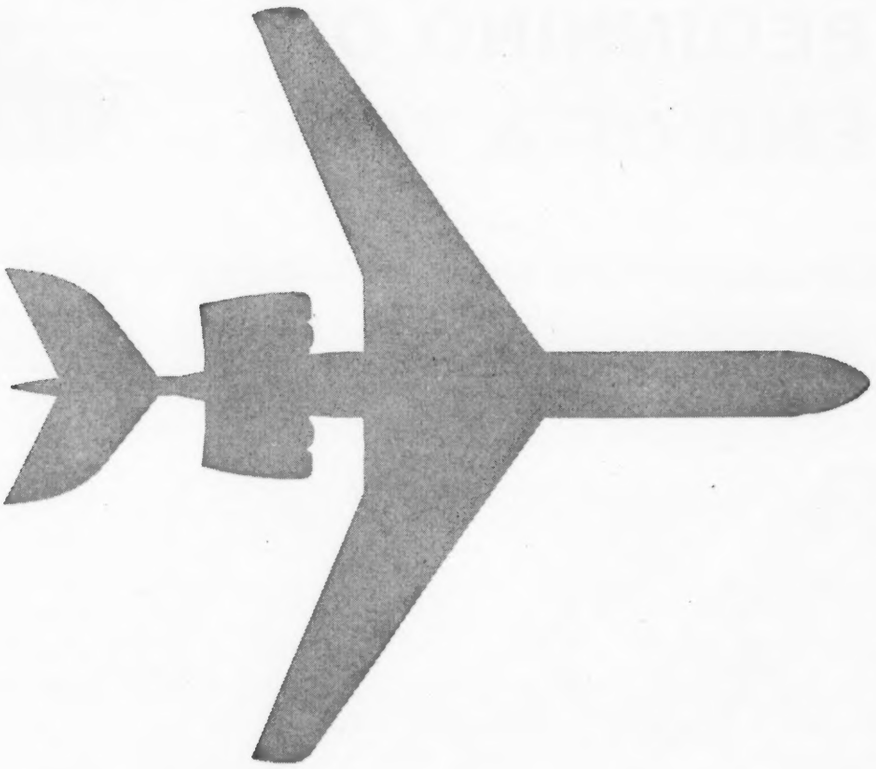

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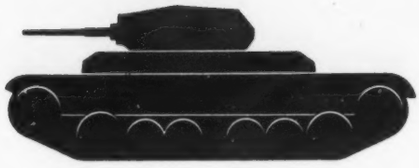

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Electronics in Aviation and Industry

● **Burroughs Corporation, Detroit, Mich.,** recently exhibited its new B5000 Information Processing System, whose technical and operational qualities permit the rational exploitation of its capacity and speeds. In recent years, the development of new and faster computers has involved increasing difficulty in programming, so that in many cases a whole staff of highly qualified—and highly paid—technicians have required several weeks to establish the programme for the solution of a complicated problem which the computer itself would only take a few minutes to solve. The need to translate a task into a form which the computer can assimilate has often meant that one of the greatest advantages of such equipment, namely its high speed, cannot be used to the full.

In developing the B5000 system the main aim has therefore been to employ all the resources of modern technology to make as full a use as possible of the capacities of the electronic computer, particularly as regards the saving of time and expense in programming. Instead of the complicated processes used hitherto, Burroughs has been using the Algorithmic Language (ALGOL), which has been in existence for the past three years, or the more recently developed Common Business Oriented Language (COBOL) to feed the programme of the problem into the computer. While ALGOL is particularly suitable for mathematical tasks, COBOL—derived from English business language—is used for programming tasks in connection with various branches of economy.

The building block principle is used, and depending on application a larger or smaller equipment can be built. A particular advantage in this connection is that the computer can be made larger or smaller without having to be reprogrammed, as it adjusts itself automatically to all modifications. The addition of a second processor, for instance, enables a problem to be solved twice as fast as with only one processor, with no change in programme.

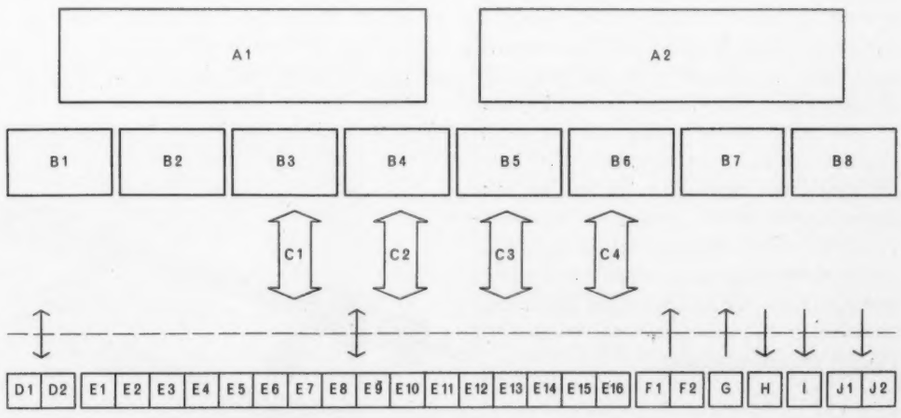
Each processor has its own master control programme, which automatically performs a variety of important functions: the selection of data and their allocation to memory modules, with simultaneous access to several such modules; selection of input/output communication channels, via which the computer receives data or presents its results; automatic by-passing of faulty computer units; self-regulation during "slack" periods between operations. In short, the master control programme allocates and monitors work, eliminating the need for human intervention and the attendant possibility of error.

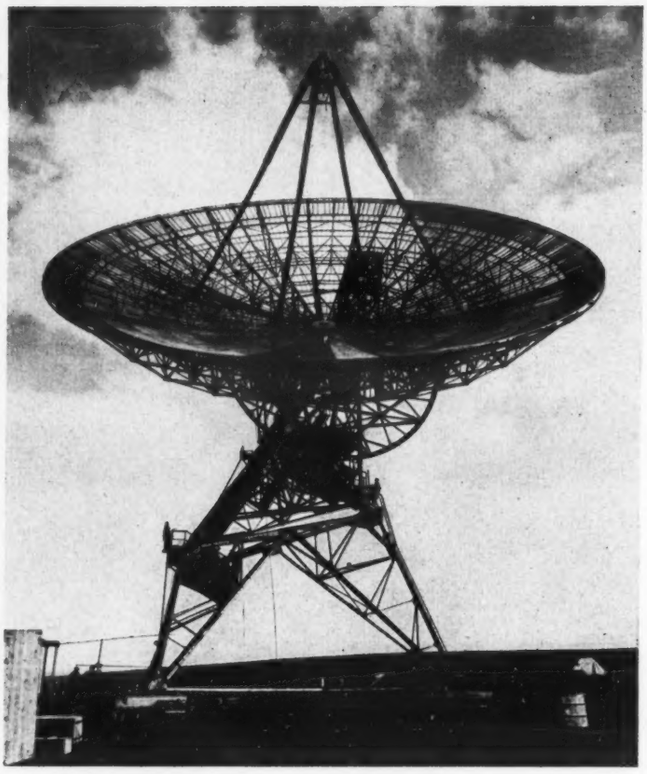
Model of a large version of the Burroughs B5000 Information Processing System. Individual computer assemblies and units can be joined together for any desired application. Even during the computing process units can be added to or removed from the equipment without reprogramming theproblem in course of solution.

The B5000 Information Processing System enables several problems to be solved independently of each other. In addition, data can be fed in and out on four channels during the computing process, enabling operating time to be fully used.

The application of the building block principle also offers a number of advantages. A standard module can be rapidly and easily adapted for over a hundred applications. This reduces by 60 percent the number of spare parts which must be kept in store, and hence running costs.

The maximum capacity of the B5000 information processing system is as follows: two processors (A) with a cycle frequency of 1 Mc/s, which can carry out an addition in an average of 3 microseconds; eight central magnetic core modules (B) with read access time of 3 microseconds; four input/output control channels (C), which can connect any memory module with any input/output device; two magnetic drum stores (D) and 16 magnetic tape stores (E) for data input or output; two punched card readers (F) and a keyboard (G) for input; finally, a fast printer (H), a card punch (I) and two line printers (J) for output.





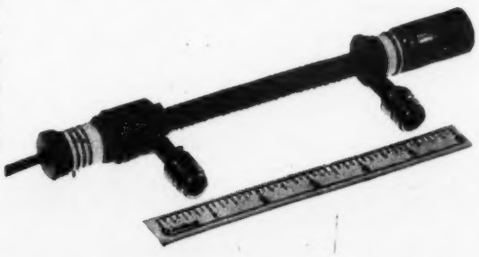
● **California Institute of Technology Jet Propulsion Laboratory Pasadena, Calif.,** which is responsible for the technical direction of the NASA Deep Space Instrumentation Facility, carried out an interesting experiment on February 11th, when a telephone message was sent from Goldstone, Calif. to Woomera, Australia, using the moon as a passive relay station. The radio waves, which were beamed to the moon by a directional antenna with a diameter of 85 ft and received by an antenna of the same size at Woomera (picture), took only 2.5 seconds to cover the distance of 455,682 miles, being transmitted on a frequency of 960 Mc/s at 7.5 kW power.

● **United Data Control, Inc., Pasadena, Calif.,** has developed an automatic annunciator, the MTA-544, for jet airliner public address systems. Up to twelve standard texts can be recorded on magnetic tapes 40 ft long, which are carried loose in magazine cartridges. The text required is selected aboard the aircraft from a simple control console. The equipment, which is extremely robust and reliable, has three magazines, which are easily interchangeable without the need for threading tape into the reproductive system. In the event of an emergency, override controls are ready to immediately interrupt any announcement.

● **National Aeronautical Corporation (Narco), Fort Washington, Pa.,** has brought three new items of radio equipment onto the market: the type UDI-2 airborne DME for 100 crystal-controlled channels in the 108-117.9 Mc/s frequency band, with a range of 0-100 nautical miles (weight 14 lb), which was developed by Narco as a "poor man's DME" under contract to the Federal Aviation Agency; the Mark 7 VHF transmitter/receiver (weight 10.5 lb) for 360 voice channels with 50 kc/s spacing in the 118.00-135.95 Mc/s band, designed primarily for installation in sports and touring aircraft; and a 12 lb combined radio and navigation unit containing a 360 channel VHF transmitter/receiver and a 190 channel navigation receiver.

● **Leach Corporation, Compton, Calif.,** has developed the "Veri-Min" command receiver (type A1W1-4C) for target drones, unmanned aircraft and satellites. The equipment has unusually low power requirements, weighs 24 oz (680 g) and has a volume of only 17.9 cu. in. (293 cm^3). It is built as a compact, super-heterodyne set designed to receive tone-modulated FM signals in the 406 to 450 Mc/s band, demodulating and filtering them to actuate control relays. The standard version of the receiver has four channels and four decoders, though packages can be added to provide additional decoder channels.

● **Sperry Gyroscope Company, Great Neck, N. Y.,** subsidiary of Sperry Rand Corporation, has developed a miniature amplifier with a high transmission power for future space communications. To achieve this high power, Sperry engineers have perfected an electron beam focusing structure for the accurate direction of highly concentrated electrical energy down the tube. The illustration of the experimental amplifier clearly shows a number of small permanent magnets made of a special alloy which are slipped over the tube like rings to form the focusing structure.



● **Hughes Aircraft Co., Culver City, Calif.,** has developed a new system under contract to the U.S. Air Force, permitting rapid and reliable air-to-ground communication even in conditions of heavy electrical interference. The "Digikey" equipment contains separate keys which enable various words or brief reports to be selected. The word or phrase selected when the pilot presses the appropriate key is sent to a memory, where it is stored until the complete text of the message has been composed. On actuation of the transmit key, the message is transmitted to the ground station, information on the aircraft call letters, position, heading and altitude being automatically transmitted with it. The transmission speed is 150 words per minute, almost double that of normal voice reporting speed. The message to be sent is first converted into digital form, after which the coded pulses obtained are transmitted to the ground station on a number of frequencies. This ensures perfect transmission even when there is considerable radio interference. On the ground, the digital signal components are reconstituted to form the original words and automatically printed for direct reading. The Hughes procedure enables reports from a large number of aircraft to be fed directly into automatic command and control systems.

● **Bell Aerosystems Company, Buffalo, N. Y.,** has received a U.S. Air Force contract to study the feasibility of building a simulator to give future astronauts a foretaste of the conditions they will encounter during their flights through space. In collaboration with the USAF Aerospace Medical Division, Bell will first investigate, in a new laboratory, whether the combination of closed-circuit television systems with models of earth, moon and planets is a suitable system for the training of astronauts. Under present plans, photographs of models of heavenly bodies and space vehicles and the image of an electronic planetarium (also to be developed by Bell) will be projected onto a curved screen, in front of which will be a realistic model of a space cabin. By synchronizing the pictures taken by a number of television cameras in different studios with the control movements of the astronaut, the latter will receive a picture which will change continuously as he proceeds on his simulated space mission. High-intensity projectors will be used to produce the glare effect that would be caused by viewing the earth and other planets in space, and a special spotlight will simulate the sun. To achieve a more realistic picture than has hitherto been possible, Bell Aerosystems Company engineers will make a comprehensive series of tests with high-resolution television equipment.

What's in the Air?

AIR TRANSPORTATION

Aerolíneas Argentinas has signed a contract with A.V. Roe Ltd. (HSG) for nine Avro 748 Series 1 transports with an option on a further five. The contract is valued at approximately £2.5 million ($7m.) and brings the total Avro 748s on order to 24. First delivery is scheduled for October 1961 for operation on the carrier's domestic network. The 48-seat Avro 748 is powered by two Rolls-Royce *Dart R.Da.6* Mk.514 propeller turbine engines.

The **Venezuelan Government** has approved Boeing 707 and Douglas DC-8 jet services by five operators between Venezuela, the United States and Europe. The carriers concerned are Air France, Alitalia, BOAC, KLM and the newly-formed Venezuelan international operator VIASA.

Seaboard & Western Airlines, a U.S. scheduled freight operator, has announced plans to carry passengers on its trans-Atlantic Canadair CL-44 flights at a rate of 3.8 U.S. cents per mile (e.g. New York-London $133). Six-abreast seating would be mechanically rear-loaded into the aircraft on pallets immediately after the cargo had been secured. No reservations would be accepted more than six hours in advance of any scheduled flight, and service would be limited to box meals. S & W is seeking CAB, IATA and European governmental approval.

Northwest Airlines has given Boeing Airplane Company an order for six Model 720B passenger transports, and has taken an option on a further six. Boeing's order book for the 720/720B models now stands at 98 aircraft.

Trans-Canada Air Lines will increase Douglas DC-8 frequency to Paris to seven flights a week by June, four originating in Toronto and three in Montreal. TCA expects to maintain the schedule on a year-round basis and has launched a major promotion campaign in Canada to boost traffic on its trans-Atlantic services to Paris, Zurich, Vienna, Düsseldorf and Brussels.

Japan Air Lines will begin scheduled Douglas DC-8 service on the Polar route to Europe on June 6th, with an initial frequency of two flights a week. JAL will operate the route Tokyo-Anchorage-Copenhagen-London-Paris in 18 hours' flying time.

British United Airways, U.K. independent operator, has signed an agreement with the Sierra Leone Government covering the formation of a new airline in Sierra Leone, and the earlier agreement between Sierra Leone and Nigerian Airways will be cancelled. The new company will operate domestic services and international routes under the Sierra Leone flag after that country receives independence this month.

Deutsche Lufthansa representatives were in South Africa last month for talks with the Department of Transport on the West German carrier's plans ot operate scheduled services to South Africa. Lufthansa has also given Boeing Airplane Company an order for 12 Model 727 passenger transports.

The KLM board has confirmed the nomination of Dr. E. H. van der Beugel to succeed General I. A. Aler as president of the company when the latter retires next May. General Aler will continue to be a member of the KLM board.

East African Airways has ordered a third *Comet 4* from de Havilland Aircraft (HSG). EAA General Manager Colonel M.C.P. Mostert says there has been a marked increase in passengers and revenue earnings since the introduction of the first two *Comet 4s* on the carrier's international routes last September.

Belgian flag-carrier Sabena will have four Sud-Aviation *Caravelle 6s* in service for the introduction of summer schedules on April 1st, and the last two of the current order are due for delivery by June. Sabena *Caravelle* operations will be stepped up to serve 22 European and Middle East points during this summer, and the carrier's DC-8s and *Caravelles* will provide jet service to 30 points on the route network.

Sabena and the Argentine operator Transcontinental Airlines S.A. are reportedly nearing agreement on a closer working relationship. Sabena may handle all Transcontinental business in the United States, with the Argentine carrier handling certain business activities for Sabena in Latin America. Reports indicate that Sabena may lease aircraft to Transcontinental for domestic operations and may acquire a minority interest (perhaps as high as one-third) in the Argentine company.

Riddle Airlines and Aerovías Sud-Americanas have agreed to merge with Riddle as the surviving company. Riddle has filed an agreement with CAB covering either the purchase of ASA-International (St. Petersburg, Fla.) stock or to exchange stock on a share-for-share basis. ASA is authorized to operate scheduled freight services between Florida and Latin American points.

Trans-Canada Air Lines ended 1960 with a $2,607,350 loss, the first in ten years, against a profit of $152,554 in 1959. Gross revenues for 1960 were 11 percent up to $148,986,526. The deficit was mainly due to a drop in average return per seat-mile flown and increased expenses for the introduction of DC-8s and Vickers *Vanguards*.

INDUSTRY

The U.S. strategic airlift transport to be built for MATS by Lockheed Aircraft to meet SOR.182 is now known as SS-476L (Support System 476 Logistic).

Hamilton Standard Division of United Aircraft Corp. is developing a new variable camber propeller under contract to the U.S. Navy. The 15-foot diameter propeller pictured here employs two sets of blades working in pairs, enabling total blade lift to be adapted to meet any desired operating conditions. The company says that use of the variable camber propeller on VTOL aircraft would permit an increase of up to 50 percent in payload or up to 40 percent in range. The propeller is currently on test at Wright-Patterson AFB, Ohio.

Flight testing of the turbine-powered Fiat 7002 helicopter is now under way at Caselle, near Turin. This helicopter is powered by a Fiat Type 4700.000 shaft turbine with a rating of about 500 h.p.

The Lockheed contract covers development and production of a fleet of 100 aircraft in a programme estimated to cost $1,000 million eventually. The first aircraft should be in service by 1965. The specification calls for a swept-wing, rear-loading transport, powered by four pod-mounted, 23,000-lb thrust turbofan engines and top speed will be 440-500 knots and service ceiling above 25,000 ft. Range will vary from 3,000 n.m. with 70,000-lb payload to 5,000 n.m. with 20,000 lb of cargo. AUW 300,000 lb with capability to operate from 6,000-ft runways. Two versions will be developed simultaneously for military and commercial cargo operations. Direct operating costs are expected to be as low as 4 cents per ton-mile. The U.S. fiscal 1963 budget will carry $98 million for the project to be added to the $30 million allocated in fiscal 1962.

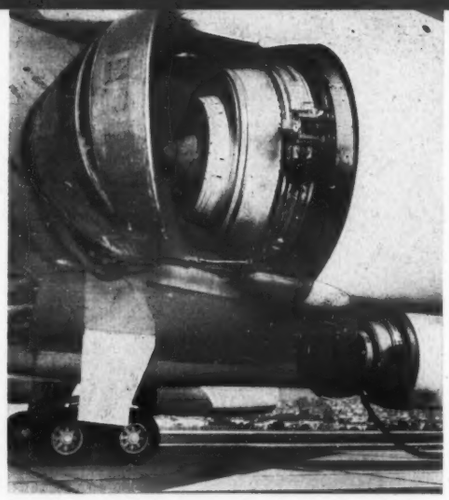
Canadair will deliver the first CL-44 to Flying Tiger Line in May, with a further two in May, two each in June, July and August, and the 10th and last in September. Flying Tiger has an option on another five CL-44s.

Seaboard & Western will take delivery of two CL-44s in June and another three in August. It has yet to be decided whether S&W will display its first CL-44 at the Paris Air Show (June). The carrier is anxious to get the aircraft into service as soon as possible, as one MATS contract calls specifically for this aircraft. Canadair's last current order—two for Slick Airways—will be delivered in October.

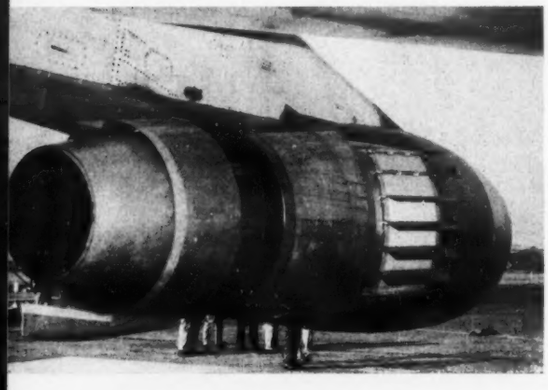
The fuselage of the Breguet 941 STOL aircraft was recently transferred by road from Villacoublay to Toulouse for final assembly. Tests of the Breguet 941 transmission system are proceeding at the Centre d'Essais des Propulseurs et Hélices at Saclay. The complete wing test bed should be working at Toulouse this month. The Breguet 941 will have four 1,250 h.p. Turboméca Turmo 3D *engines with Ratier-Figeac propellers.*

All airframes for current CL-44 orders will be off the Canadair production line by about June. No further firm orders have been booked, but the Pakistan Government wants two aircraft for PIA and is currently investigating the financial angle. In New Zealand, there are plans for Tasman Empire Airways to use CL-44s to airlift chilled meat to the U.S. West Coast. Lufthansa, KLM, PanAm and American Airlines are all interested, with KLM appearing to be the most likely prospect.

Convair 990 deliveries to American Airlines, Swissair, SAS and REAL will be delayed at least four months to December of this year due to problems uncovered during flight testing. Difficulties include insufficient elevator force with the CG in the rearmost position, insufficient braking power, and slight flutter in both wing tips requiring relocation of the outboard engine nacelles 28 in. rearwards. Convair says delivery schedules will be accelerated later to close the gap. Modification of the first Convair 990 off the production line started last month.



The Convair 990 has thrust reversers designed and produced by General Electric especially for the CJ-805-23 aft fan engines. The clamshell doors shown in the picture reverse both the primary jet exhaust from the inner circle and fan air discharged from the outer circle.



Installation of the Pratt & Whitney JT3D-1 turbofan engines on the Series 50 Douglas DC-8 provide for diversion of both primary and fan stream gas discharge. Upper picture shows the nacelle, cowling and thrust reversing devices in the normal take-off and cruise positions. Lower picture shows the reverse thrust position with the external cover moved aft pneumatically and internal clamshells closed. This dual action exposes the cascades and diverts the gas forward.

First Sud-Aviation Caravelle 6R for United Air Lines (20 on order) had logged 76 hours in flight testing up to March 7th. Sud-Aviation will deliver the first four aircraft between April 30th and June 30th, and the *Caravelle* should be in service on UAL's routes in July. A further two are due for delivery at the end of July, one at end-August, two in September, three in October, three in November, four in December and the 20th in January 1962.

The Sud-Aviation production line now includes five airframes for the *Caravelle VII* prototypes, the first to be equipped with the General Electric CJ-805-23 powerplants. First flight of the VII version has now apparently been put back from September to December this year. The *Caravelle VII* includes modifications to an American Airlines' specification, and Sud-Aviation has high hopes of winning orders for the aircraft in the U.S. market.

Pye Telecommunications received orders valued at £40,000 ($112,000) from the East German Government at the Leipzig Fair. Equipment to be supplied to the DDR includes an ILS for Dresden International Airport and the latest VHF ground-to-air communications equipment for Berlin-Schönefeld Airport and the East German area.

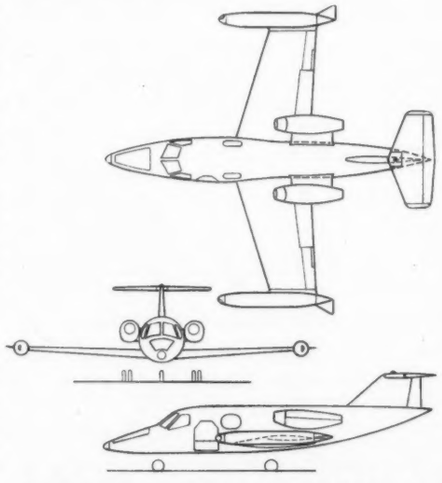
Westland Aircraft has a £550,000 ($1.5m.) order from the Ghana Government for three *Whirlwind* helicopters for the Air Force. Contract includes spares, and delivery is scheduled for this autumn. One *Whirlwind* will be equipped as a six-seat de luxe executive aircraft for transporting government officials, and the others will be standard versions for rapid conversion to civil, ambulance or rescue work. All three helicopters will be fully instrumented for all-weather operations. The series 3 *Whirlwind* is powered by a de Havilland *Gnome H1000* free-turbine engine and has eight to ten seats.

The eleven-nation Preparatory Commission to outline a programme for a European Space Research Organization held its first session in Paris last month. Nations represented were Belgium, Denmark, France, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, U.K., and West Germany. Chairman Sir Harrie Massey (U.K.) said that he had found a very strong will to cooperate among the member countries.

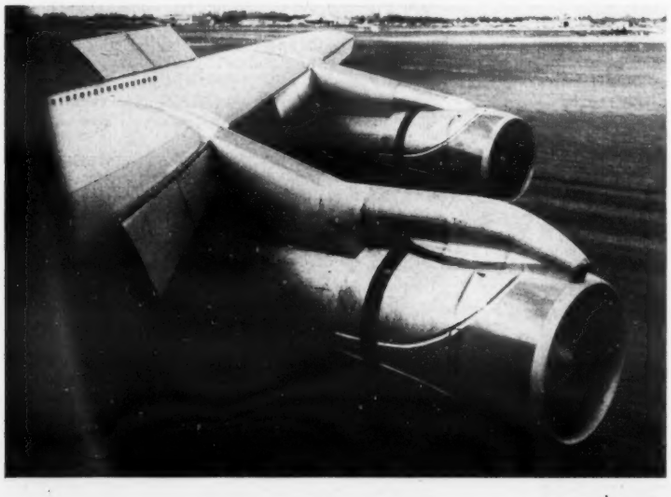
The Commission approved a budget of NF 935,000 ($187,000), and set up two working groups. The first, under the chairmanship of Professor L. Hulten (Sweden), will study the purely scientific programme to be recommended. This group is meeting again in Stockholm early this month to establish the main lines of work, broken down into the first-year requirements and the longer-term programme. The second working group will study legal, administrative and financial questions for the projected organization. The next full meeting of the Preparatory Committee is scheduled for mid-May in the Netherlands (location not yet decided).

France's Professor Pierre Auger is Executive Secretary, with J. Mussard (Switzerland) as his deputy. The two Vice-Chairmen are Professor L. Broglio (Chairman of Italy's Space Research Committee), and Professor H. C. van der Hulst (Helden Observatory, Netherlands).

A Pilatus Porter small transport and multi-purpose aircraft, manufactured by the Pilatus Aircraft Works, Stans, is being fitted with a Turboméca Astazou for experimental purposes. Flight testing should begin in mid-April. No data have yet been published on the turbine-powered *Porter*, but considerable improvements are expected in rate of climb and take-off and landing performance.



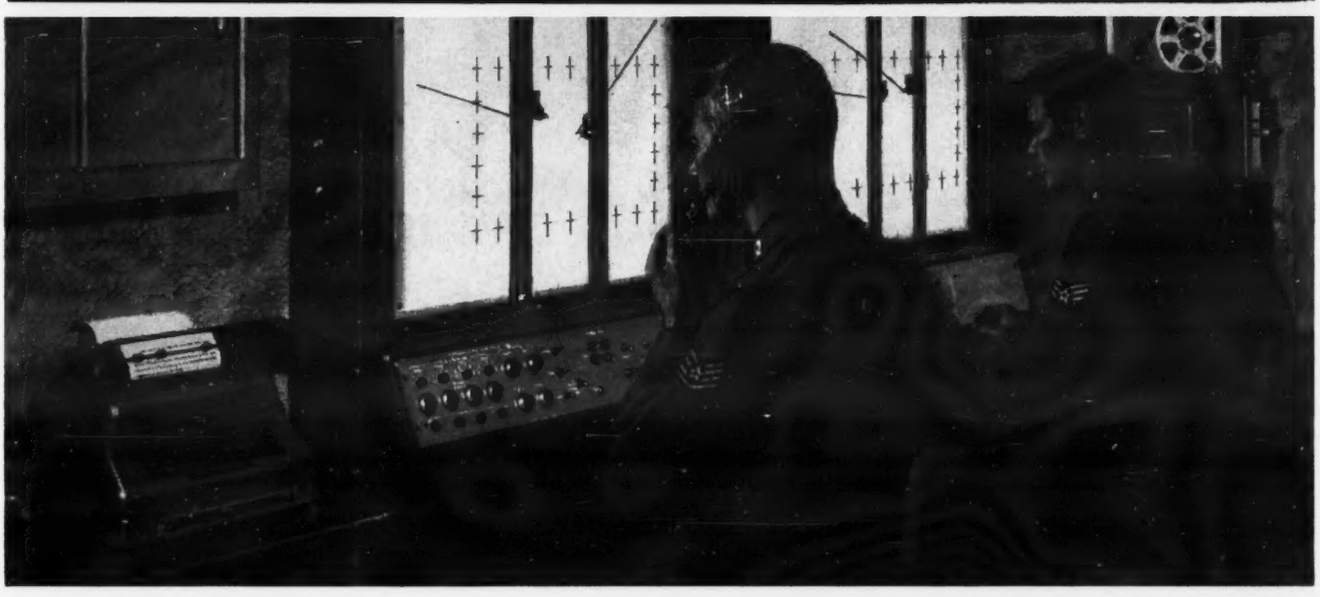
Provisional three-view drawing of the SAAC.23 seven-seat business aircraft which will be powered by two General Electric CJ610-2B jet engines. This aircraft is based on specifications of the Swiss-American Aviation Corp. of Wilmington, Delaware and Aviation Development Inc. of St. Gall, Switzerland, and is readily adaptable to civil and non-combatant military duties such as reconnaissance, ambulance or liaison work.



The Boeing 720B has received FAA certification following 500 hours' flight testing since its first flight on October 6th, 1960. The 720B is equipped with Pratt & Whitney JT3D fan engines, and the picture shows the forward fan reverser ring in the aft position exposing the reverser vanes. Wing spoilers on top of the wing are in the extended position as are the full-span leading edge flaps.

Nord-Aviation is reportedly working on a STOL version of the *Noratlas* freighter. The aircraft is to be fitted with a blownwing and small auxiliary jets (probably supplied by Turboméca), according to reports from Paris.

Gruppo Componenti CSF is a new organization grouping four autonomous Italian electronics and electrical component manufacturing companies, with headquarters at 1B Via Giandomenico Romagnosi, Rome. Managing Director is engineer Abel Farnoux, who is also Managing Director of the four Italian companies concerned. These are: Microfarad SpA of Milan: Ducati Elettrotecnica SpA of Bologna; Mistral SpA of Sermoneta (Littoria Province); Circe SpA of Pontinia (Littoria). The group also has Italian distribution rights for all components manufactured by the French CSF company (Compagnie Générale de Télégraphie Sans Fil).



Cubic all-weather tracking system gives detailed analysis of ADC scoring missions

When a rocket or missile streaks from the armament bay of an interceptor over the Eglin Gulf Test Range and hurtles toward a target drone, a unique Cubic tracking system goes to work. Called MATTS for Multiple Airborne Target Trajectory System, it gives the Air Defense Command a complete running account of every phase of a scoring mission and prints out a full record of the intercept problem for later analysis.

MATTS has already demonstrated an unusually high level of reliability in continuous ADC operation. It has been scheduled as primary scoring instrumentation for ADC's next biennial weapons meet (Operation William Tell '61) to be held on the Eglin Range in October.

MATTS operates day or night, in any kind of weather, continuously measuring and plotting the trajectories of the interceptor, the missile and the target drone. The system tells everything about the mission, including the distance and direction of the missile from the target, and from the interceptor, at the time of simulated burst.

Cubic precision electronic tracking systems, of which MATTS is just one example, are in world-wide use for scoring, range safety, air traffic control, satellite geodesy and radar/telemetry acquisition. For information, write Dept. AW-102, Cubic Corporation, San Diego 11, Calif.

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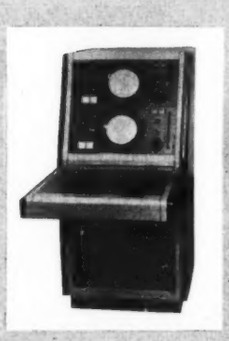

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Combined DF systems employing SERVOFLIGHT® Model 55 VHF and Model 10 UHF Doppler Direction Finding Systems dwarf all others by comparison

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Reliability—Thorough testing for sensivity, accuracy, and site error suppression. Stacked VHF/UHF antenna configuration—designed for installation on buildings, central towers, or directly on ground. Special patented features suppress parasitic interaction and fill in "nulls" in the elevation plane caused by ground reflections, thereby eliminating counterpoise, avoiding installation difficulties. Modern circuitry tremendously reduces power consumption, cuts excessive heating, increases system reliability, and provides a modern DF system that will stay modern for years to come.

Compactness—Bearing indicator display units and controls are compact enough to be installed in the control room. Receivers and other electronic units may be housed at a considerable distance without degrading system performance.

Expandability—Built-in provisions to facilitate expansion and re-arrangement to meet future needs and avoid obsolescence. Complete versatility with respect to system arrangement and operation.

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HIGH-PRECISION VHF RECEIVER
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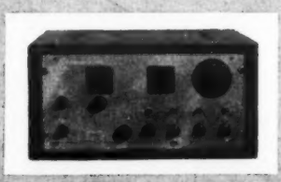

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the best helicopters for high-altitude operations

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LANDING ON MOUNT DEO TIBAA (19,698 ft) IN THE HIMALAYAS ON NOVEMBER 6th, 1960, WITH TWO PERSONS ON BOARD AND 550 lb OF BAGGAGE AND FUEL

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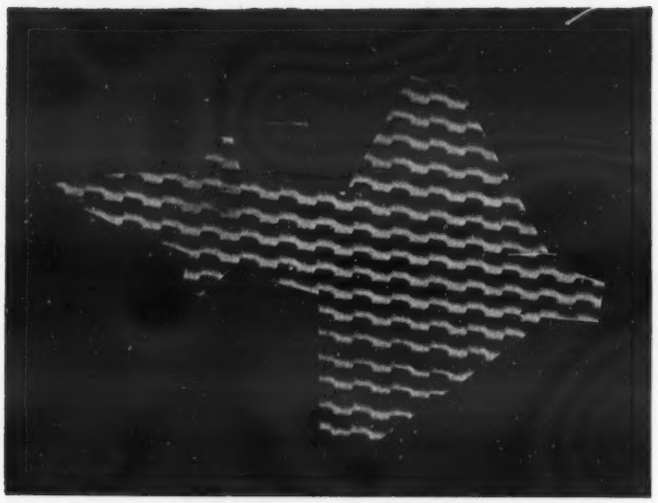

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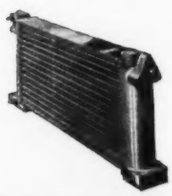
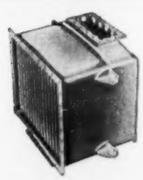
IN THE ALUMINIUM HEAT EXCHANGER



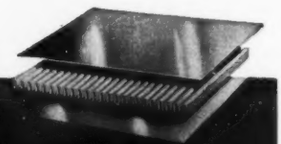
- Oil coolers
- Heat exchangers for electronic equipment cooling circuits.

- Engine supercharger intercoolers and cabin air coolers...

These are some of the applications of CEMAT heat exchangers.



Constructed of plates interleaved with corrugated metal, the CEMAT heat exchanger can be mass produced by furnace brazing.



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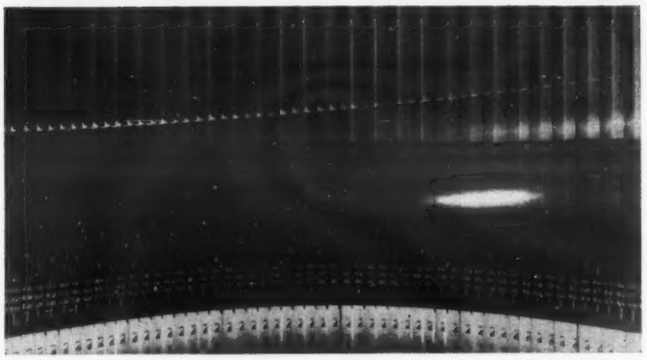

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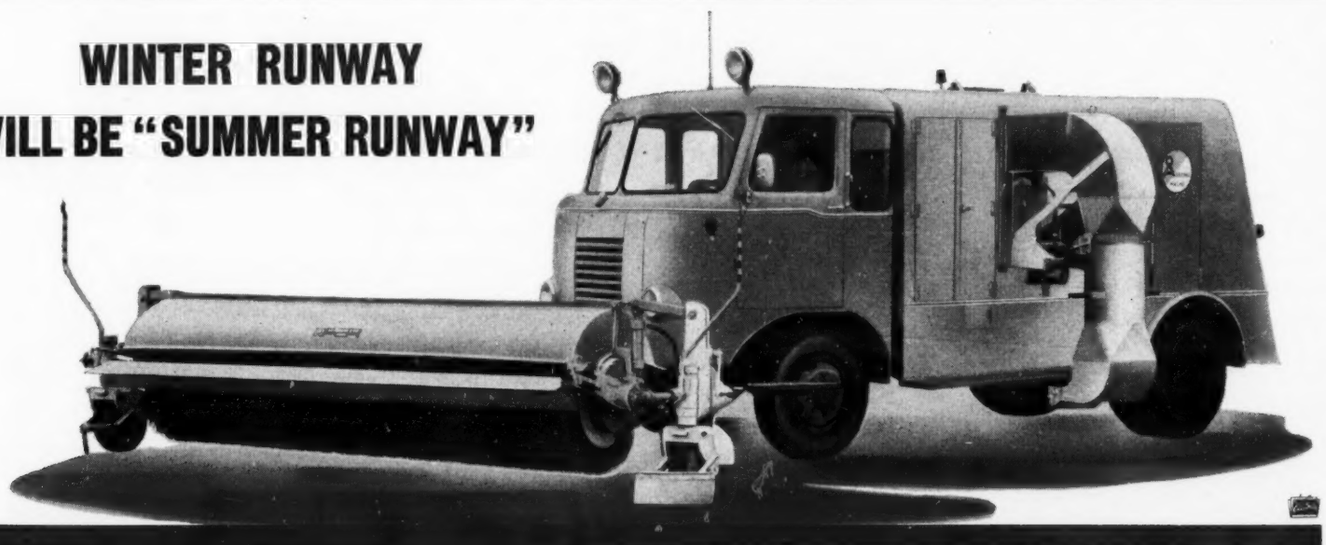

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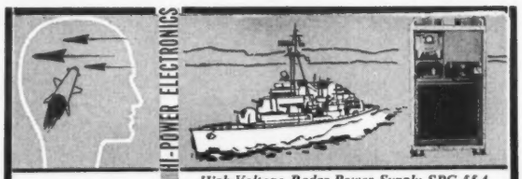

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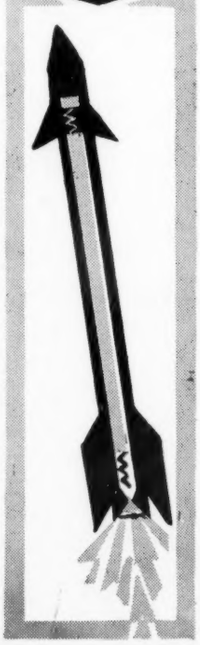

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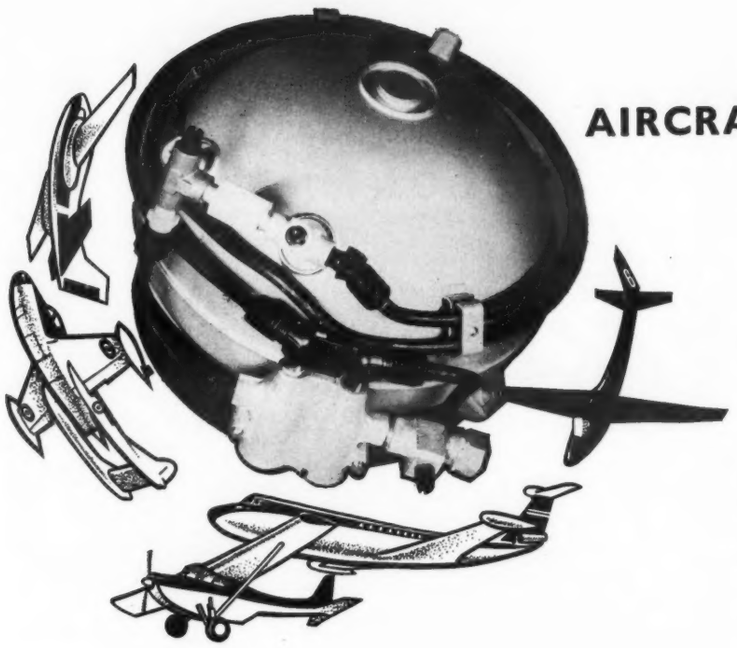

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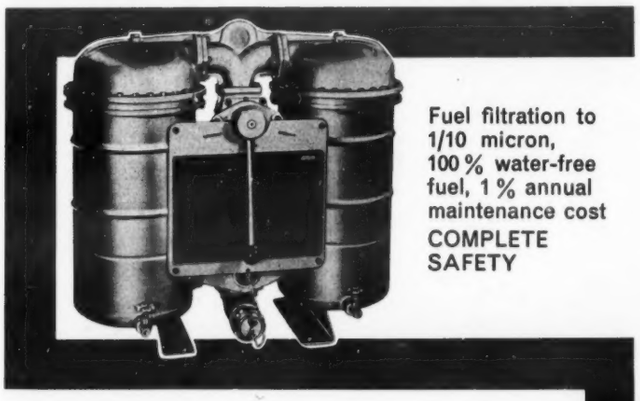

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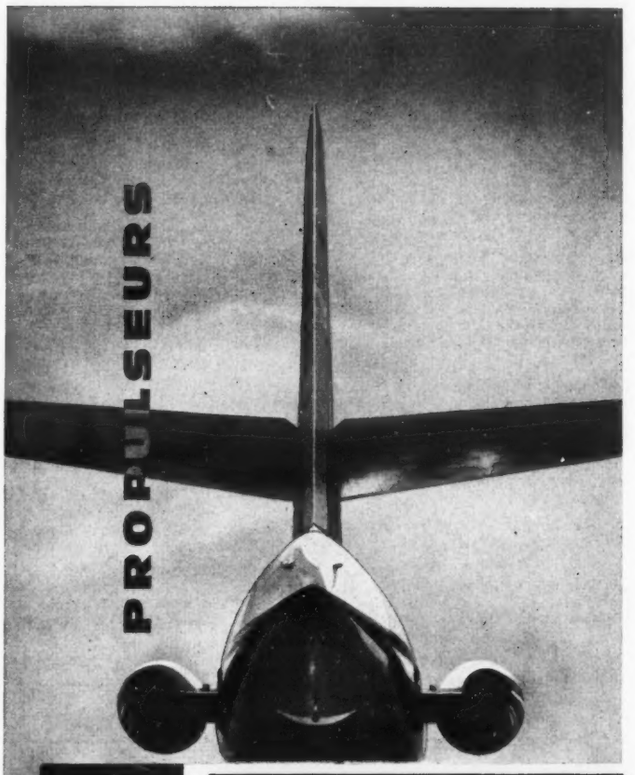

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Air France, Paris 439
L'Air Liquide, Paris 506
Alitalia, Rome 508
Alvis Limited, Coventry 409
Ampex, Redwood City, Calif. 410-411
A. B. Asbrink & Co., Malmö 509
Avions Louis Breguet, Paris 433

Bell Aerosystems, Buffalo, N.Y. 398
Bendix International, New York 405, 474-475
Bombrini Parodi-Delfino, Rome 510
Bristol Siddeley Engines Ltd., Coventry . . . 442
British Aircraft Corp., London 495-498
British Petroleum Co. Ltd., London 459

Collins Engineering Corp., Culver City, Calif. . . 514
Compagnie Générale de Télégraphie sans Fil, CSF, Paris 413
Contraves Italiana S.p.A., Rome 473
Costruzioni Aeronautiche Giovanni Agusta, Cascina Costa (Gallarate) 511
Cubic Corp., San Diego, Calif. 503

Deutsche Lufthansa S.A. Cologne 472
Dumont Laboratories, New York 509

Edo Corporation, College Point, N.Y. 400
EFA, Paris 415
Electric Auto-Lite Co., New York, N.Y. 404

Fiat S.p.A., Turin 412
Flughafen GmbH., Stuttgart 507
FXR Inc., New York 510

Garrett Corp., Los Angeles, Calif. 402
General Electric Co., Schenectady, N.Y. . . . 418-419
General Precision Inc., New York 422-423

The de Havilland Aircraft Co. Ltd., Hatfield . . . 424
Hawker Siddeley Aviation, London 417, 478
Hispano-Suiza, Bois-Colombes 508
N.V. Hollandse Signaalapparaten, Hengelo . . 420
Hughes Aircraft Co., Culver City, Calif. . . . 430-431

Iberia, Madrid 512

Jeppesen & Co. GmbH., Frankfurt 510

KLM, Royal Dutch Airlines, The Hague 506

Laboratory for Electronics, Boston, Mass. . . . 476

Marconi Italiana S.p.A., Genoa 514
Marconi Wireless Telegraph Co., Chelmsford 432, 436, 460
MATRA, Boulogne 514
McDonnell Aircraft Corp., St. Louis, Mo. . . . 516
Middle East Airlines, Beirut 512
Minneapolis-Honeywell Regulator Co., St. Paul, Minn. 438
Monsanto Chemical Co., St. Louis, Mo. 461

NARCO, Teterboro, N.Y. 510
Nord-Aviation, Châtillon s/Bagneux 515

Normalair Ltd., Yeovil 511
North American Aviation Inc., Downey, Calif. . 416
Northrop Corporation, Hawthorne, Calif. . . . 434-435

Omnipol, Prague 477

Panair do Brasil, Rio de Janeiro 512
Piper Aircraft Corporation, Lock Haven, Pa. . . 428
The Plessey Co. Ltd., Ilford 462, 471

SEPR, Villejuif (Seine) 507
Servo Corporation, Hicksville, N.Y. 504
SFENA, Neuilly 513
Siemens-Schuckertwerke A.G., Erlangen . . . 427
Smiths Aviation Div., Wembley 440
SNECMA, Paris 441
Sofrance S.A., Limoges 513
Etablissements Souriau & Co., Billancourt . . . 513
Standard Telephones & Cables Ltd., London . 414
Ad. Strüver GmbH., Hamburg 403
Sud-Aviation, Paris 505
Svenska Aeroplan A.B., Linköping 437

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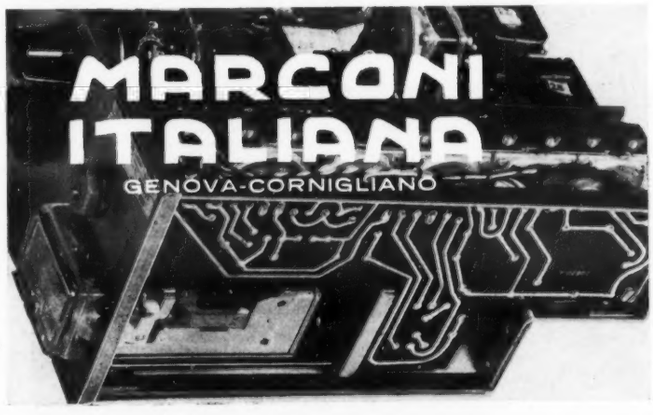

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